POWER

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Making a Life

AT A DINNER that I attended recently, one of the speakers remarked that "We are not here to make a living; we are here to make a life."

A curiously complex and intricate product, that life; a mixture of actions and abstentions both in part creditable, and both in part regrettable, of opportunities embraced or rejected, of achievements and of failures.

And so tied in with the lives of others that a single act may make or mar the product or fate of an entire group.

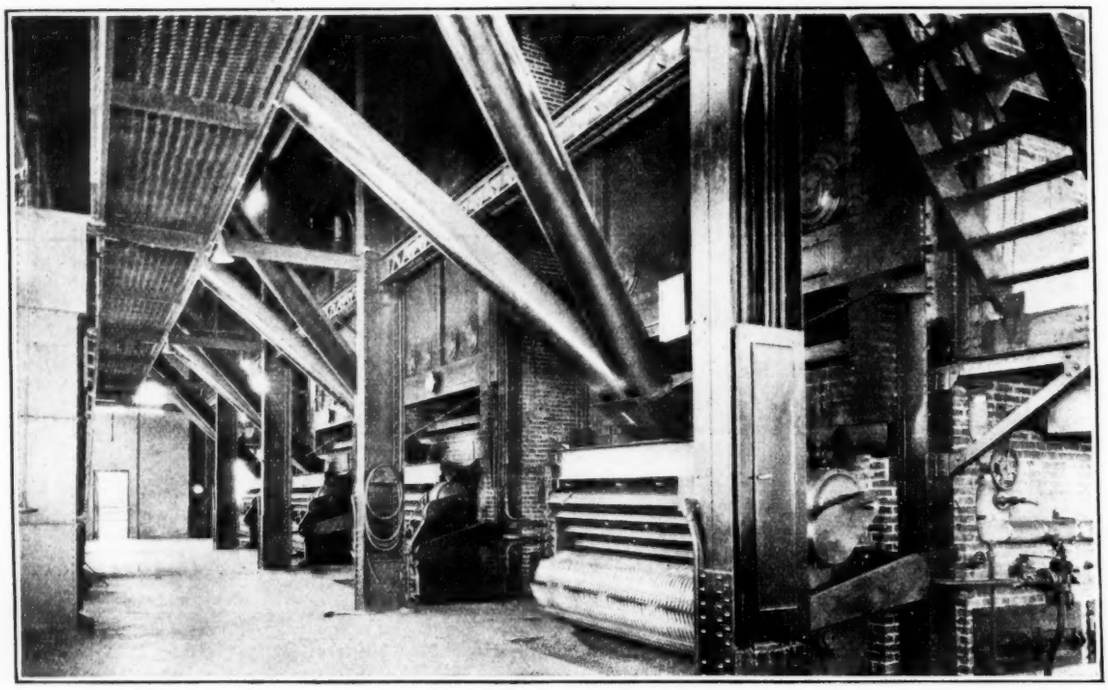
And this ineffable thing that we call civilization is a complex of millions of human lives in the making, and of their reactions upon one another.

The helpful achievements of the few, the greedily prosecuted interests of the selfish, the domination of the strong, the submissiveness of the weak, the charitable forbearance of the constructively patient, the rifts made by vindictive envy and jealousy, aid or impede the working out of this intricate fabric and its realization in the highest development of the race.

A kindly word, a lift over a rough spot, encouragement and commendation, the condoning of a false step, have put many a man upon his feet and enabled him to bring his life's work to a creditable and happy end.

When one unrolls and contemplates the life that he has made, it is not the pleasures that he has enjoyed nor the gains that he has effected, nor empty honors won by selfish seeking, that will present the fairest aspect to his eye. The brightest spots will be those which portray the happiness of others made possible by his thoughtfulness and sacrifice; the love and friendship that he has inspired, the things that he has done to make others better off and the world a better place to live in. And the blemishes will be the needless pain that he has caused, through harshness and inappreciation and thoughtless neglect of opportunities for doing good and conferring pleasure.

F. R. Low



Each boiler is served by a six-zone forced-draft chain-grate stoker

New Boiler Plant of Byproducts Coke Corporation

Four Boiler Units Equipped with Forced-Draft Chain Grates and Special Furnaces for the Burning of Coke Braize, with Front and Rear Arches and Side-Wall Cooling

AT THE South Chicago Works of the Byproducts Coke Corporation, at 112th St. and Torrence Ave., a new boiler plant of four units has been erected to operate in conjunction with an installation of 110 Koppers coke ovens in two blocks of 55 each, designed for byproduct recovery.

In the older installation steam was supplied partly by waste-heat boilers utilizing the heat in the gases from the ovens, supplemented by a number of hand-fired units. As the new ovens are regenerative, utilizing their own waste heat, a primary boiler plant was required, but again steam is generated from a waste product in the form of coke braize. This is burned on forced-draft chain grates with furnaces specially designed for the fuel. This furnace is the outstanding feature of interest in the new plant.

Reference to the illustrations will show the general arrangement of the new plant, whose function is to supply steam to the gas blowers, air compressors and other equipment of the coke plant, to carry the byproduct process load and in addition furnish some steam to an adjacent plant of the Peoples Gas Light & Coke Co. The building is of brick and steel with plenty of glass area and monitor construction over the center of the house and the overhead conveying equipment. An innovation is an outside monorail system with traveling cage installed for window washing.

Measuring 50x112 ft. in plan and 62 ft. high from the basement floor to the roof trusses, the building is installed on concrete piling, all above grade, with sufficient railroad clearance under the ash hoppers at the yard level to provide access for standard railway cars to remove the ash. All steam piping from the plant is carried overhead on trestlework, double or loop lines being provided in each case, which are thoroughly insulated and properly sized to give a velocity of flow approximating 6,000 ft. per minute.

Within the plant there are four boilers in single settings baffled for three passes and each containing 6,118 sq.ft. of steam-making surface. Convection superheaters are placed between the first and second banks of tubes. Although the boilers have been designed for 250 lb. pressure, operation at present is at 150 lb. gage and 180 deg. superheat at 150 per cent of rating. This compromise was necessitated on account of some of the older equipment still retained. As soon as it has been replaced, the operating pressure in the boiler room will be 225 lb. gage.

Each boiler is equipped with a six-zone forced-draft motor-driven stoker. Special arches are provided front and rear with open spaces above to ventilate the arch steel. Beginning at the front, a fantail ignition arch is followed by a furnace arch 8 ft. long. This is shown in the sectional elevation of the plant, Fig. 1, as well

as the arch ventilating space formed by an offset of the front wall of the setting. This view also shows the steel supporting beams carrying through to the side walls and the standard ornamental half front of the boiler partly covering the offset. This construction naturally reduces the combustion space in the vicinity of the tubes, but in a fuel containing only 3 to 7 per cent volatile, this is not important, particularly as the furnace is practically surrounded by refractory and combustion should be complete before the gases pass the restricted area between the front and rear arches.

With sufficient refractory material at the front of the furnace to insure proper ignition of the fuel, which is almost pure carbon, the rear arch was designed to reflect heat on the latter portion of the fuel bed and bring about a minimum of carbon loss to the ashpit. Here much the same construction as for the front furnace arch provides ventilating space above the arch and steelwork to support the vertical walls, front and rear of the mud drum. It will be seen that the rear arch extends well in front of the mud drum, leaving a throat slightly less than 4 ft. wide between the two arches over the fourth zone of the stoker. With this construction much of the fly ash so prevalent with the fuel burned will be returned to the grate and passed on to the ashpit instead of being carried through the boiler as in the ordinary type of setting. A more important function of this restricted area, however, is to mix the gases properly and insure complete combustion before they come in contact with the heating surface.

Fly ash also was responsible for more side-wall cooling than usual, owing to its tendency to adhere to the brickwork, then melt and in dripping down onto the fuel bed cause clinker formation. Side-wall water boxes at the five line, connected into the circulation

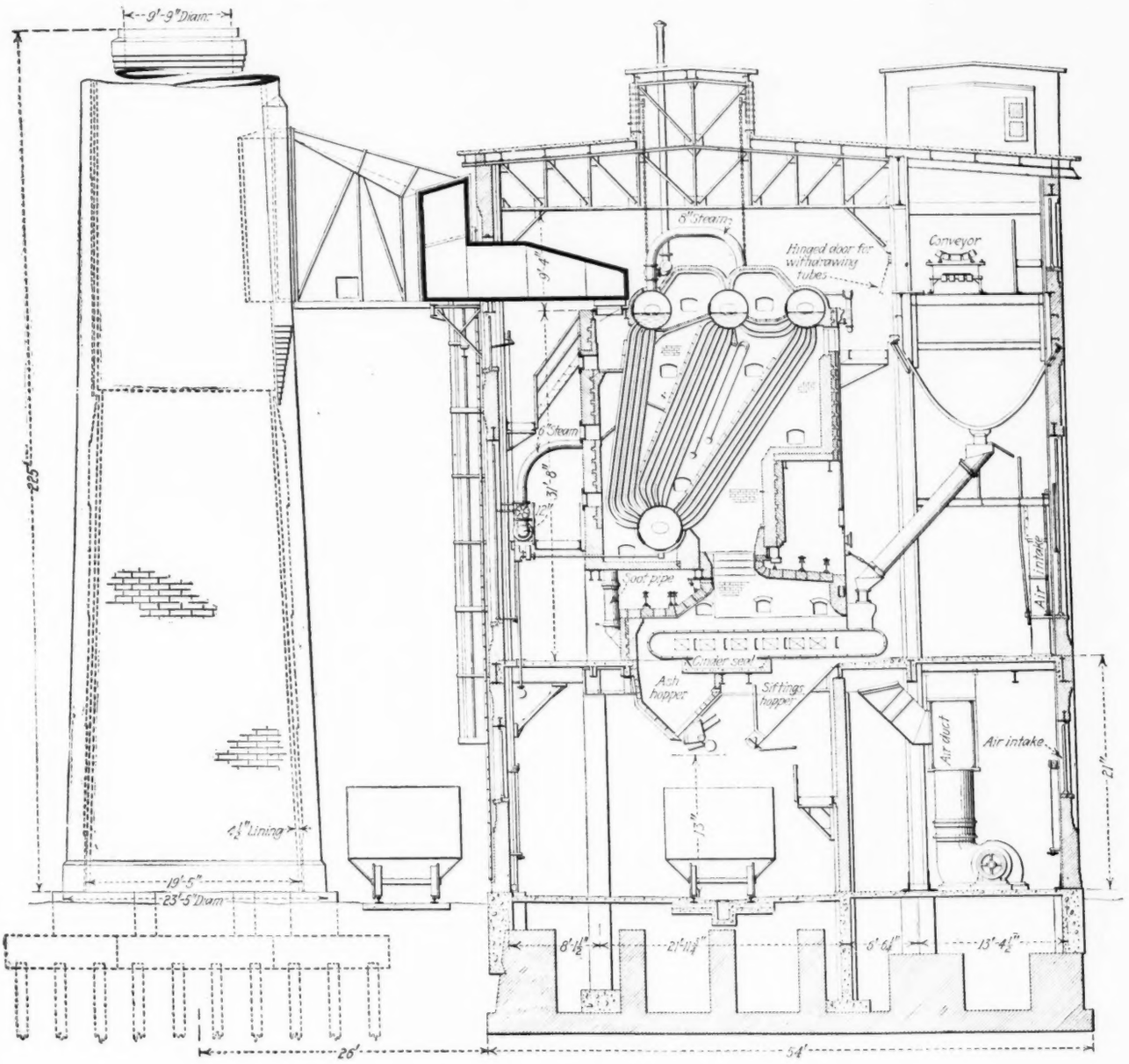


Fig. 1—Sectional elevation through boiler house

of the boiler, and for 6 ft. above, air-cooled side-wall blocks, afford ample protection. The area covered by the blocks is of tapering section conforming to the shape of the furnace as limited by the arches. Provision for air admission to these blocks is shown on the side wall in Fig. 2. Connection is made to the main air duct of the stoker on the respective side of the setting, the air passing to a manifold, thence through the various ducts into either the second or third stoker compartment or into both, beyond the compartment dampers. The differential pressure between the inlet and outlet determines the amount of air going through the ducts and additional regulation is provided by a damper at the intake. The amount is a comparatively small percentage of the total air required for combustion, but is sufficient to prevent the trouble from fly ash referred to and in addition provide a certain amount of preheated air to speed up combustion.

Double soot pipes are provided for the transfer of fly ash and soot from the chamber below the mud drum to the ash hopper. In these pipes the lock damper system has been used, so that soot will flow freely to the ash hopper without agitation or interference from the boiler draft. Below the stoker will be noticed the cinder seal, the brick-lined airtight ash hopper equipped with steam-operated gates and the siftings hopper under the front portion of the grate. Both of these hoppers discharge to a railway car underneath, and their functioning can be observed from the elevated platform at the side.

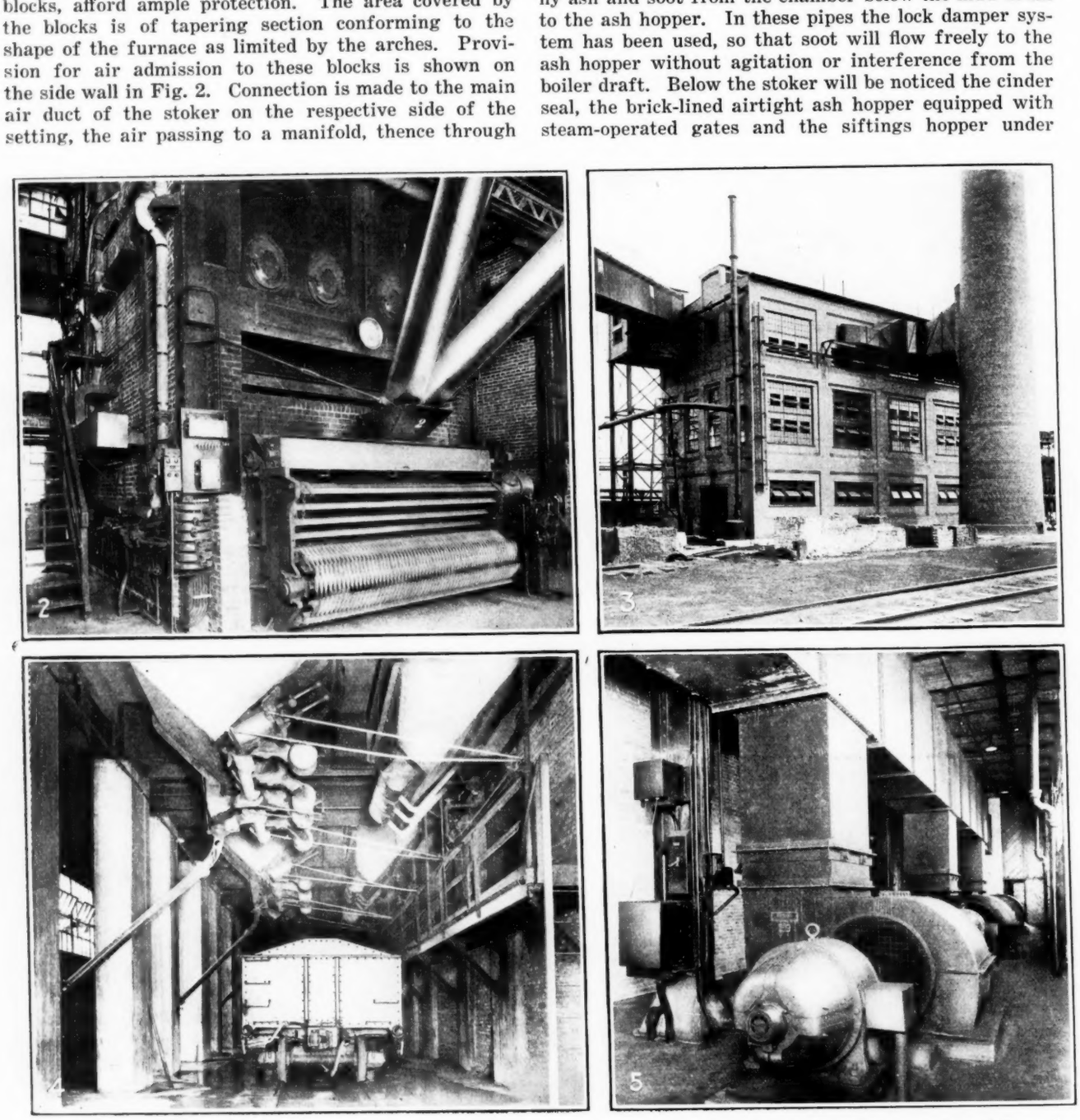


Fig. 2—Close-up of boiler front showing instruments and stoker drive. Fig. 3—Note outside stack and breeching. Fig. 4—Railway car spotted to remove ashes and siftings. Fig. 5—Three forced-draft fans discharge to a common duct

Three motor-driven fans supply the air for combustion, any two of which will operate the plant at full capacity. They discharge into a common air duct from which two branches lead to each boiler. The air for combustion may be drawn down through the boiler room into the fan room through a louver-controlled air

intake or may be taken directly from the outside through a swinging sash. Over the fire, draft control has been provided to operate the boiler dampers and the blast dampers, and to control the stoker motors.

Coke braize collected from the ovens is delivered to an inclined belt conveyor rising to the bunker level and discharging to a horizontal conveyor with automatic tripper running over the bunker. As coke braize tends to hang up in the bunker at an acute angle, double spouts lead to each stoker, the two spouts being brought to the central hopper of a fuel spreader of the spiral-screw type, which feeds both ways to insure an even filling of the stoker hopper. The spreader has a ratchet drive from the stoker operating gear. A pressure plate at the end of the hopper is designed to prevent an overfeed of fuel by holding out the ratchet.

No feed-water equipment was installed in the new plant as the older apparatus, consisting of pumps and a hot-process continuous water-softening system with lime-and-soda treatment, were retained in their original location. Delivery is made to the new boiler house, and the flow is measured by a venturi meter of the indicating, integrating and recording type, so arranged that it also may be used to measure the feed to any one boiler by replacing a filler in the feed line with the venturi tube. Feed-water regulators control the flow to the individual boiler.

In the few weeks of operation of the new plant no definite data have been secured, although detailed tests are to be made at a future date. The installation has been giving excellent satisfaction, the entire four boilers operating up to an average of 200 per cent of rating for a month at a time. As high as 40 lb. of the braize per square foot of grate area have been burned, and the evaporation over the period of a month averages 6.35 lb. of water per pound of the fuel as fired. Naturally, this takes into account banking periods, variations in load, etc., and with a fuel containing an average of 11.5 per cent moisture and 13.4 per cent ash. Improvement is expected when full automatic control has been established.

The new plant was designed by the Freyn Engineering Company, consulting engineers, of Chicago, and installed under their supervision. M. A. Tack is the chief engineer having charge of its operation.

Where a number of coils are involved in a short-circuit in an armature, not only will these coils be heated, but the machine will act as if it were heavily overloaded. When starting, if the machine is a motor, the armature will revolve slowly with a jerky motion and will draw a heavy current from the line, which will cause the starting resistance to become abnormally hot. If an attempt is made to cut the resistance out of circuit, the protective device will open. With a generator the prime mover will give every indication that it is starting the machine under a heavy overload. However, with either a motor or generator a section of the winding will increase to an abnormal temperature, and to those familiar with such symptoms there can be little doubt as to the cause of the trouble.

DATA ON PRINCIPAL EQUIPMENT OF BOILERHOUSE, BYPRODUCTS COKE CORPORATION

GENERAL

Location of plant	South Chicago, Ill.
Character of service	Coke plant steam load
Fuel	Coke braize

BOILERS AND SUPERHEATERS

Manufacturer	Babcock & Wilcox Co.
Type of boiler	Stirling, Class 13
Number installed	4
Heating surface per boiler, sq.ft.	6,118
Furnace volume, cu.ft.	1,232
Size of tubes, in.	3¼
Boiler pressure, lb. gage	150 present 225 future
Superheater, convection	Babcock & Wilcox Co.
Location of superheater	Between first and second banks of tubes
Surface per superheater, sq.ft.	436
Superheat, deg. F. at 150 per cent of rating	180
Soot blowers	Marion Machine Fdry. & Supply Co.

BOILER SETTINGS

Distances:	
Floor to center line mud drum, ft.-in.	12–0
Floor to center line steam drum, ft.-in.	31–8
Front wall to bridge wall, ft.-in.	10–6
Type of setting	Brick with air-cooled side-wall blocks
Setting contractor	Bishop Contracting Co.
Arches	American Arch Co., Inc.
Side-wall blocks	Waite & Davey

STOKERS

Manufacturer	Riley Stoker Corp.
Type	Traveling chain grate
Size, ft.	10 x 17
Grate area, sq.ft.	168
Drives—Reliance motors, hp.	3

FORCED-DRAFT FANS

Manufacturer	B. F. Sturtevant Co.
Number installed	3
Type	Turbovane, No. 90, Design 5
Capacity of each, c.f.m. at 65 deg. F. against 4-in. static pressure	40,000
Speed, r.p.m.	1165
Drive, 40-hp., d.-c. motor, 625 to 1,250 r.p.m.	Reliance Electric & Engineering Co.

STACK

Built by	The Rust Engineering Co.
Type	Perforated radial brick
Diameter	9 ft. 9 in.
Height above base, ft.	225

BRAIZE HANDLING

Type	Overhead bunker served by belt conveyor
Conveyor manufacturer	Heyl & Patterson, Inc.
Size of conveyor, in.	36
Speed of conveyor, ft. per min.	450
Capacity, tons per hour	300
Fuel spreaders at stoker hopper	Universal Coal Spreader Co.

ASH HANDLING

Type	Direct delivery to railroad car at yard elevation
Ash gates, steam operated	Beaumont Manufacturing Co.
Number and size per hopper	Two 30x48 in.

CONTROL SYSTEM

Manufacturer	Shallcross Control Systems Co.
Equipment controlled	Stack dampers, blast dampers and stoker motors

INSTRUMENTS

Draft gages	Lewis M. Ellison
Recording thermometers	Bristol Co.
Recording pressure gages	The Foxboro Co., Inc.
Venturi meter	Builders Iron Foundry

MISCELLANEOUS

Piping	B. Floersheim & Co.
Pipe covering	Keasbey & Mattison Co.
Steam and water valves	Crane Co.
Stop and check valves	Golden-Anderson Valve Specialty Co.
Blowoff valves	Wm. Powell Co.
Safety valves	Ashton Valve Co.
Water columns	Reliance Gage Column Co.
Steam traps	Crane Co.
Feed-water regulators, Copes	Northern Equipment Co.

Determining the Vacuum Correction Curves for Turbine Units

By L. J. LEVIT
Assistant Engineer, United Electric Light & Power Company, New York City

IN ORDER to compare the water rate curve obtained by test with either the guarantee curve or the performance of another turbine, it is essential to reduce the test results to some standard conditions. Direct comparison of the water-rate curves is likely to be misleading unless they are reduced to the standard conditions. Unfortunately, the establishment of a common standard (something analogous to "sea level") is not always feasible owing to the wide range of operating conditions.

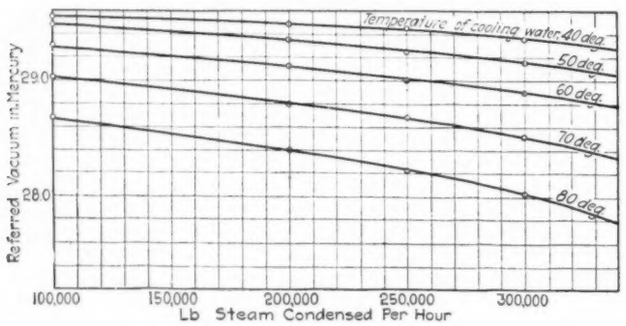


Fig. 1—Limitations of cooling water temperature make vacuum tests preferable in winter

The turbine guarantee usually specifies certain steam conditions (initial pressure and superheat, and exhaust vacuum) and is based on closed bleed valves. As it is very difficult to maintain all the conditions specified by the guarantee, certain corrections are agreed upon for the moderate departures from these conditions. Usually the manufacturer furnishes his estimates of the corrections obtained either from the test of a similar turbine or computed from the turbine design.

If the manufacturer's guarantee is based on unit efficiency (Rankine cycle ratio) instead of the water rate the corrections for the variations of the steam conditions can be dispensed with for the moderate variations met with in the test. If the steam conditions vary over a wide range, the Rankine cycle ratio should be corrected for such variations. The Rankine cycle ratio tends to decrease with the increase of initial pressure and also with reduction of superheat. It should be specified whether the guarantee is based on the governor or the throttle-valve conditions. If it is desired to compare the performance of the whole unit, the throttle-valve conditions should be used. When comparing the turbine elements proper, however, it is desirable to use the governor-valve conditions.

The initial steam conditions (pressure and superheat at the throttle valve) will vary but little with the load on the machine and the season of the year. The manufacturer's guarantee can be used without jeopardizing the accuracy of the results. The problem is more difficult, however, when dealing with the vacuum correction. The vacuum may vary both with the load on the machines and with the season of the year. It is also dependent on the cleanliness of the condenser. Both the load and the seasonal variations of vacuum are quite large. It may be inadvisable to use the manufacturer's estimates of the vacuum corrections without verifying them by the test.

Inasmuch as the lowering of vacuum with the increase of load is greater when the circulating-water temperature is high, it would be advisable to conduct both the water rate and vacuum tests in the winter in order to obtain more uniform conditions of exhaust at all loads. Cold circulating water can be adjusted to give better range of vacuum for a test. It gives a more uniform vacuum at low temperatures. A typical set of vacuum curves for a large surface condenser is given in Fig. 1, illustrating the importance of cooling-water temperature, and hence the season for the turbine test.

Very often it is desired to obtain a rough approximation of the vacuum correction without resorting to any measurements outside of those necessary for the regular water-rate test. In order to estimate the vacuum corrections, it is necessary to know the dimensions of the last wheel and the generator efficiency of the turbine set.

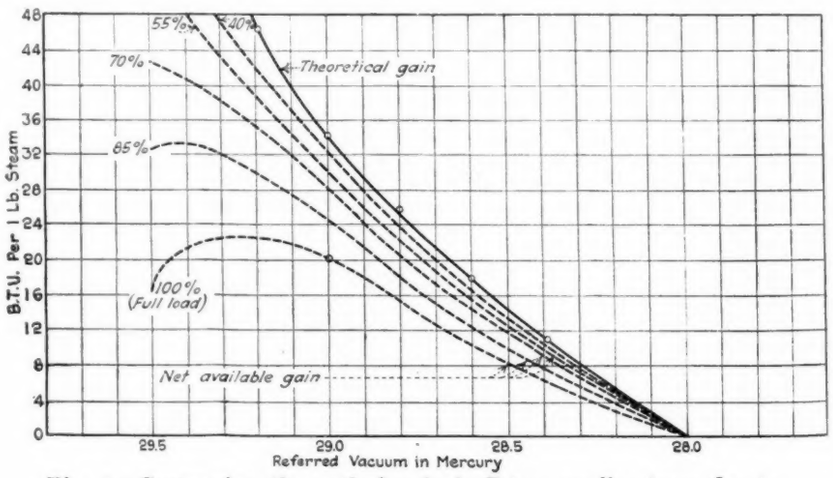


Fig. 2—Comparing theoretical gain in B.t.u. per lb. steam due to increase of vacuum with actual gain

The vacuum correction for a given range of vacuum will depend on the vacuum for which the turbine is designed. The correction will be greater for the partial load than for the full load. The reason is obvious enough; leaving losses at low loads are much smaller than at the full load.

Turbine losses can be divided into the following classes.

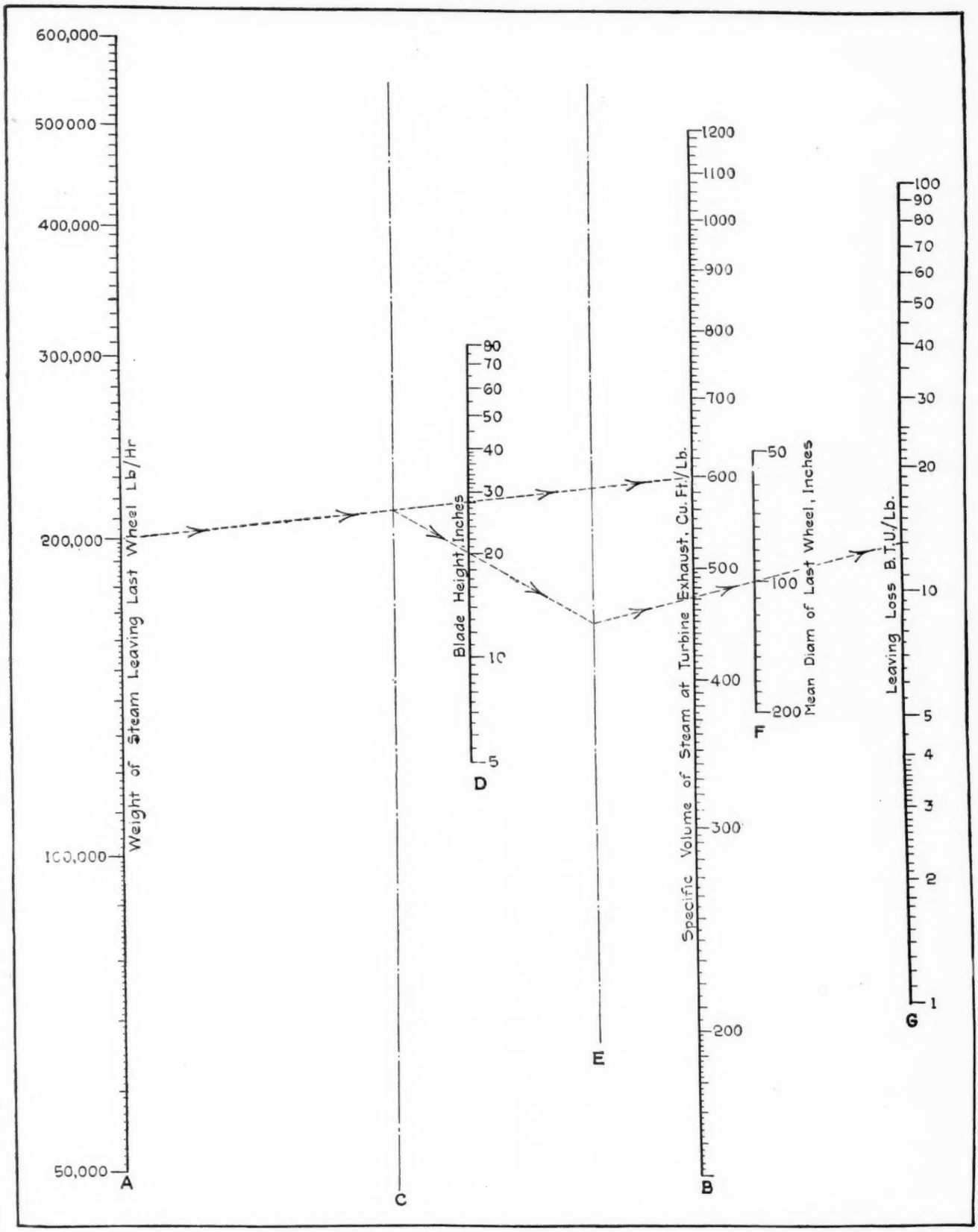


Fig. 3—Leaving loss, determined from steam per hour, blade height, mean blade diameter, and specific volume assuming that steam is exhausted in an axial direction

Example—200,000-lb. steam per hr., specific volume 600-cu.ft. per lb.; blade length 20-in., mean diameter 100 in. Sequence of using scales same as alphabetical order, shown by dotted lines.

Join 200,000 on the scale (A) with 600 on the scale (B), mark the point where this line intersects the index line (C), join the point on index line (C) with 20 on the scale (D), mark the point where this line intersects index line (E), join the point on the index line (E) with 100 on the scale (F), read the answer on the scale (G). Answers will be high at loads above or below the most economical.

Internal Losses: Blade; nozzle; disk friction (impulse type); leaving velocity; gland and stage leakage and blade pumping.

External Losses: Bearing friction; power to drive governor and oil pump; radiation and gland leakage.

Inasmuch as the speed of the alternator remains unchanged, its external losses are not affected by the change of vacuum. All internal losses are affected to some extent. The increase of vacuum above a certain point generally will tend to reduce the efficiency ratio. Owing to increased heat drop per stage, particularly that of the last few stages, the blade and nozzle friction losses are augmented by the increase of the steam velocities.

Leaving Loss Principally Affected

The diagram efficiency, however, may be affected either way, depending on the speed ratio that the last few stages are designed for. At certain vacuum the diagram efficiency for the last few stages is maximum and this falls off when the vacuum, and hence the steam speed ratio, are either increased or decreased. This vacuum will depend on the load on the unit.

The only loss that is affected to a large extent by moderate change of vacuum is the leaving loss. For all intents and purposes the effect of other losses on the vacuum correction can be neglected, provided the change of vacuum is not too great. The leaving loss will vary about as the square of the total volume of the steam handled by the last row of blades. Inasmuch as the specific volume of steam is increased rapidly with the increase of vacuum, or greater absolute back pressure, the point is reached when the leaving loss offsets the gain due to the increased heat drop.[1] A typical set of curves for a certain turbine giving the gain in B.t.u. per pound of steam due to the increased vacuum is illustrated by Fig. 2.

The point where the actual gain curve would cut the zero line at the left corresponds to the limiting vacuum. The limiting vacuum, for the reasons already cited, is lower for high loads than for light loads. These curves seem to bear out the contention that the main reason for the change of the vacuum correction with the load is the leaving loss. The theoretical gain is increased with the decrease of load due to the higher available energy at the governor valve when the throttling method of governing is used.

Economical Vacuum and Limiting Vacuum

The fixed charges grow rapidly with increased vacuum due to the enormous increase of the volume of steam then handled by the condensing equipment. The operating charges are also increased owing to the increase of power for the condenser auxiliaries. As the capacity of the turbine is limited by the vane area at the last wheel, lower vacuum would permit utilization of higher rotative speeds for a given capacity by reason of the decreased steam volume handled by the last wheel. Higher vacuum is necessarily accompanied by the lower hotwell temperature. It is clear from the reasons cited that the most economical vacuum will be lower than the limiting vacuum.

Lengths of blades must not exceed a certain proportion of the wheel diameter, so that the exhaust area is limited. Permissible peripheral speed can be raised by employing blades having a variable cross-section.

The exhaust area can be increased by using low rotative speeds. The reduction of rotative speed, however, is accompanied by the increased number of stages, and consequently a higher unit cost. Sir Charles Parsons suggested the use of a separate cylinder for the last few rows of blades, as exemplified by the Parsons unit at the Crawford Avenue Station installation of the Commonwealth Edison Company.[2] The steam is admitted to the low-pressure cylinder at about two pounds absolute and is expanded to the exhaust vacuum.

As a low rotative speed of 720 r.p.m. is employed, the exhaust area can be made quite large, thus reducing the leaving losses. The speed of 720 r.p.m. for the whole unit would be undesirable because of the excessive size and cost. A large number of stages would necessarily increase the number of cylinders. The advantages of a combination similar to that suggested by Sir Charles Parsons are self-evident. Higher vacuums could be economically utilized with such an arrangement.

Multi-flow Exhaust

The double- or semi-double-flow principle is employed quite extensively by the manufacturers of the reaction turbines. This arrangement, however, increases the size and cost of the unit. Owing to the increased number of stages the turbines of this type are usually compounded when large capacities are involved.

The multiple-flow-exhaust system[3] does away with some of the drawbacks of the double-flow turbines. The blades of the wheel before the last are divided into two concentric belts. The steam entering the outer belt is expanded to the exhaust vacuum, while the steam flowing through the inner belt is passed with a very little change of pressure. The steam leaving the inner belt is expanded to the exhaust vacuum in the last blade row. According to Kearton one additional row of exhaust blades increases the available exhaust area 60 per cent, two additional rows 120, and three additional rows 170 per cent.

Inasmuch as bleeding decreases the amount of steam handled by the last stage, it favors the economical use of higher vacuums. It also affords means of utilizing low-grade heat that otherwise would be lost in the condenser, thus further improving the station efficiency.

The leaving loss, assuming steam discharged axially, can be computed from the formula,

$$L = \left(\frac{V \times W \times 144}{\pi \times D \times l \times r \times 3{,}600 \times 223.7} \right)^2$$

in which

L = Leaving loss in B.t.u. per lb. of steam;
V = Specific volume of steam at exhaust, cu.ft. per lb.;
W = Steam, lb. per hour leaving last row of blades;
D = Mean diameter of last wheel blade row, inches;
l = Length of last row of blades, inches;
r = Blade thickness coefficient.

It may be conveniently used for calculating the probable gain with changes of vacuum in connection with turbine operation.

Example: An impulse turbine rated for 50,000 kw. at 1,200 r.p.m. mean diameter of last wheel blade row 150 in., length of blades 35 in., coefficient of thickness $r = 0.95$. Test readings at about 29 in. vacuum are

[1] This was brought out in an article by B. C. Sprague in the Dec. 16, 1924, issue, "Determining the Leaving Loss and Limiting Vacuum of a Steam Turbine."

[2] Described in the Nov. 4, 1924, issue.

[3] Described in the May 15, 1923, issue.

as in Table I. Assume 700 kw. external loss at all loads. Calculate the probable vacuum correction curve in percentage of loss that would occur if vacuum were lowered one inch.

TABLE I—TEST READINGS OF LARGE TURBINE

Run	Load Kw. at Switchboard	Total Steam per Hour As Tested Lb.	Steam Lb. Throttle	Pressure Gage Inlet	Superheat at Throttle Deg. F.	Referred Vacuum In. Mer.	Generator Efficiency Per Cent,
1	21,450	230,100	244	117	186	29.18	94.2
2	28,540	299,300	238	150	188	29.18	95.25
3	36,800	379,000	246	209	187	29.18	96.00
4	44,200	457,500	247	240	189	29.16	96.5
5	52,150	553,200	248	240	192	29.12	96.7

In order to find the specific volume of steam at the exhaust for use in this formula, it is first of all necessary to find the total heat in a pound of steam at the exhaust pressure, and then refer these two quantities to a Mollier diagram for ascertaining the moisture or superheat from which the specific volume can be found.

The power supplied by the turbine at the coupling equals the generator output divided by its efficiency, so that 21,450 ÷ 0.942 = 22,700 kw. Since 700 kw. is expended in external losses, the entire energy given up by the steam passing through the turbine is 22,700 + 700 = 23,400 kilowatts.

The amount of steam used per kilowatt output of the turbine vanes equals 230,100 ÷ 23,400 = 9.82 lb. of steam per internal kilowatt. Since each kilowatt of energy represents 3,412 B.t.u., it follows that 3,412 ÷ 9.82 = 347 B.t.u. utilized per 1 lb. steam in the turbine.

From the steam tables it will be found that one pound of steam contains 1,308 B.t.u. under conditions at the throttle, which is the same content as after being throttled to 117 lb. gage at the inlet. Now the heat per pound at the exhaust is equal to this minus the heat utilized in the turbine, or 1,308 — 347 = 961 B.t.u.

Figuring the Leaving Loss

The quality of the steam at 29.18 in. vacuum containing 961 B.t.u. can be obtained from a Mollier diagram, from which the volume per cubic foot of steam can be found with suitable tables and calculations, which is 692 cu.ft. per pound.

The vertical line as a Mollier diagram, referred to as entropy corresponding to 1,308 B.t.u. and governor valve pressure (117 + 14.7 lb. abs.), is equal to 1.708 on the entropy scale. The heat per pound of steam corresponding to 29.18 in. referred vacuum and 1.708 entropy is equal to 908 B.t.u., representing heat in exhaust of a perfect turbine. The energy theoretically available by expansion, or Rankine heat drop from governor valve to exhaust is 1,308 — 908 = 400 B.t.u. per lb. The Rankine heat drop from governor valve to 28.18 in. vacuum is 1,308 — 948 = 360 B.t.u. The theoretical gain from 28.18 in. vacuum to 29.18 in. vacuum is equal to 400 — 360 = 40 B.t.u. The leaving loss at 29.18 in. vacuum is

$$L\,29.18 = \left(\frac{692 \times 230{,}100 \times 144}{\pi \times 150 \times 35 \times 0.95 \times 3{,}600 \times 223.7}\right)^2 = 3.3 \text{ B.t.u.}$$

Following the actual expansion line from the governor-valve pressure to the exhaust vacuum (29.18 in.), we find in the same way as before that specific volume of steam at 28.18 in. is about 340 cu.ft. per lb.

Leaving loss at 28.18 in. exhaust vacuum is,

$$L\,28.18 = \left(\frac{340 \times 230{,}100 \times 144}{\pi \times 150 \times 35 \times 0.95 \times 3{,}600 \times 223.7}\right)^2 = 0.8$$

The leaving loss is less at 28.18 in. by 3.3 — 0.8 = 2.5 B.t.u. per lb.

The net loss at 28.18 or gain at 29.18 in. vacuum equals approximately the theoretical loss minus the decrease of leaving loss, or 40 — 2.5 = 37.5 B.t.u. per lb. In per cent of energy utilized under test conditions, this is 37.5 ÷ 347 = 10.78 per cent. This, correctly speaking, represents the approximate per cent loss that would occur if the vacuum were lowered one inch below conditions of test.

Figuring out each of the remaining runs as just described, per cent corrections for energy utilized at various loads at 28.18 in. can be tabulated as in Table II. The energy correction factors are derived from the per cent corrections. The water-rate correction factors are the reciprocals of these, from which per cent water-rate factors are obtained.

TABLE II—LOSS IN PER CENT WATER-RATE AND IN ENERGY UTILIZED PER POUND OF STEAM WHEN VACUUM IS LOWERED ONE INCH BELOW THAT ON TEST IN PER CENT OF THAT UTILIZED PER POUND OF STEAM AT 29.18 IN. VACUUM

Number of Run	B.t.u. per Lb. Decrease of Leaving Loss	B.t.u. per Lb. Available Energy Loss	Per Cent Less Energy per Lb. Steam at Lower Vacuum	Factor for Energy Correction	Factor of Water-Rate Correction	Water-Rate Correction in Per Cent of Rate on Test*
1	2.5	40	10.78	0.8922	1.121	+12.1
2	4.23	40	10.22	0.8978	1.114	+11.4
3	6.78	39	9.17	0.9083	1.101	+10.1
4	9.88	38	8.08	0.9192	1.088	+ 8.8
5	14.45	38	6.18	0.9382	1.066	+ 6.6

* The values for vacuum corrections obtained by this method will be a little high for loads below and above the most economical load. This is due to the assumption that steam leaves the last row of blades in an axial direction.

In order to avoid the time and labor required in working out this formula, the chart in Fig. 3 has been made up, which is based on this, being constructed for the value of $R = 0.95$. This will give an approximate value that is sufficiently accurate for many problems. Assume, for instance, that total steam $W = 200{,}000$ lb. per hour; steam volume, $V = 600$ cu.ft. per lb.; the blade length, $L = 20$ in.; the mean diameter of the wheel $D = 100$ in. Fig. 3 indicates how this example would be worked out by utilizing the vertical lines marked A, B, C, etc., in succession.

Join 200,000 on scale A with 600 on scale B and mark the point where this line intersects the vertical line C. This intersection should be connected with 20 on scale D, and where the latter extended, crosses E, a point should be located. This point on the index line E should be joined with 100 on scale F, the line extended to G and the answer read on the scale G to the right.

Powdered bituminous coal will explode only when it is confined and in suspension in the air; that is, when it is in the form of a dust cloud. Under this condition the dust must be ignited by a flame or static sparks, and the intensity of explosion depends on the extent of the cloud and the degree of confinement. Unconfined, the action is rather a slow, sluggish and smoky combustion. When lying in a bin, coal dust will not explode if a burning stick is thrust into it. Therefore, to prevent an explosion, dust clouds and flames must be kept apart.—*Bureau of Mines Bulletin No. 237.*

Steam issuing from the discharge of a high-pressure trap is not proof of steam leakage. Wherever water under pressure and at a temperature above 212 deg. is released to the atmosphere, about one per cent will flash into steam for each ten degrees by which the original water temperature exceeds 212 degrees.

Operation of Synchronous Motors for Power Factor Correction

By S. H. MORTENSEN
Electrical Engineer, Allis-Chalmers Manufacturing Company

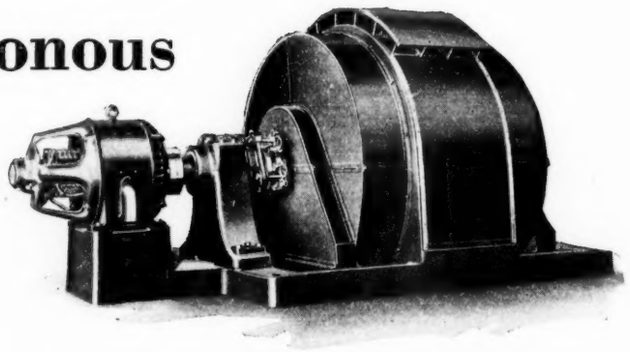


Fig. 1—Synchronous condenser rated at 5,000 kva. with direct-current exciter

THE mechanical design of a synchronous motor to be operated as a phase modifier for voltage regulation and power-factor correction aims at the production of a machine of low first cost, small space requirements and low operating losses. It is of the self-starting, salient-pole type, and its general appearance is similar to that of a modern high-speed waterwheel-driven generator. As no mechanical load is transmitted either to or from the modifier and its overspeed requirements generally are limited to the 25 per cent recommended by the Standardization Committee of the American Institute of Electrical Engineers, it is practical to operate modifiers at higher peripheral velocities for a given output than would be permissible on waterwheel-driven generators. The shaft diameter is limited through its deflection and the proportioning of the several rotor parts by the stresses corresponding to the overspeed. The rotor journals are made of as small a diameter as the bearing heating will permit, thereby keeping down the cost of the design and reducing the bearing friction losses to a minimum.

An additional problem in the mechanical design of the modifier presents the squirrel-cage winding which is provided for starting and bringing the rotor up to speed as well as for damping purposes after the machine is in synchronism. The squirrel-cage winding is generally composed of a number of bars embedded in the face of the rotor poles. These bars are short-circuited by means of self-supporting rings *R* as shown in Fig. 2. This design, however, does not meet the more severe requirements of large high-speed rotors, and for these machines a construction as shown in Fig. 3 has proved satisfactory. This type of squirrel-cage winding was originally developed in connection with the design of heavy-starting-duty synchronous motors used for rolling-mill service. As may be seen, the damper bars are totally inclosed in the pole faces; their projecting ends are welded or brazed into a copper end plate *P*, which in turn is doweled to the rotor pole end plate. Radial self-supporting links *L* form the connections between the squirrel-cage and a short-circuiting disk, *D*, which is part of the rotor spider. With this construction the several parts forming the squirrel-cage winding are self-supporting. This construction, furthermore, allows considerable leeway in the choice of the material and cross-section of the different parts forming the squirrel cage, which is particularly helpful where high starting and pull-in torques as well as damping characteristics are required. This type of squirrel-cage winding has had a thorough tryout in connection with synchronous motors used in varied industrial installations.

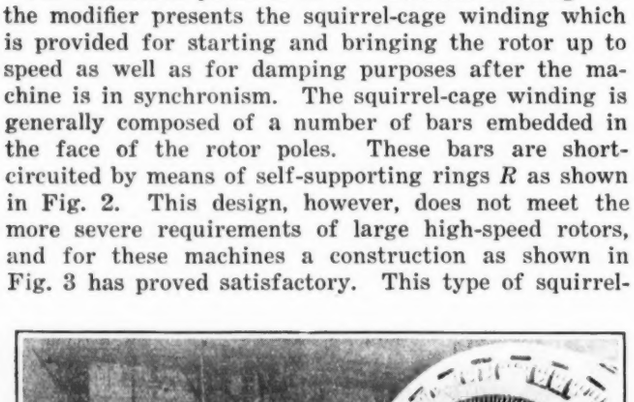


Fig. 2—Rotor and stator for the machine, Fig. 1

The mechanical strength of the stator yoke and the supports of the free ends of the stator coils must be ample to meet the stresses inherent to short-circuits near or in the stator windings. Fig. 4 shows how the end windings are laced to the supporting rings *R* to prevent movement of the windings.

The ventilation of the stator and rotor windings presents a problem similar to that met with in the design of large high-speed generators. Synchronous condensers in sizes up to 1,000 kva. are generally made open type and operated at 1,200 r.p.m. Modifiers covering the ratings from 1,000 to 7,500 kva. are mostly operated at 900 r.p.m. and from 10,000 kva. to 20,000 kva. at 720 r.p.m. Machines with a capacity in excess of 1,000 kva. are generally made of the inclosed type. Fans mounted on the rotor, as at *F*, Fig. 2, draw ventilating air in through the stator end covers and force it over the surface of the rotor coils and the free ends of the stator coils through the several ventilating ducts in the stator core out of the machine.

By providing suitable ducts leading to and from the machine, its air supply may be controlled and cool, clean ventilating air assured. Where such is not obtainable, air filters, washers or coolers should be installed. In addition, to insure uniform ventilation throughout the stator and rotor windings the inclosed type of ventilation reduces the windage losses and also the operating noises inherent to high-speed machines. Fig. 1 shows a 5,000-kva. modifier. To obtain clean ventilating air for the machine in this installation, it was necessary to extend its air intake ducts to the

top of the building. The air is discharged through the top and bottom of the stator into the station.

In commercial operation great importance is placed upon the modifier efficiency and its design is aimed at the production of a machine with low losses per kilovolt-ampere output. As bonus and penalty clauses covering the guaranteed losses frequently are included in modifier contracts, it becomes important to determine these losses accurately. This may be done after the machine is installed or prior to its shipment from the factory.

If the phase modifier has a starting motor of suitable and known characteristics, the modifier's losses may be

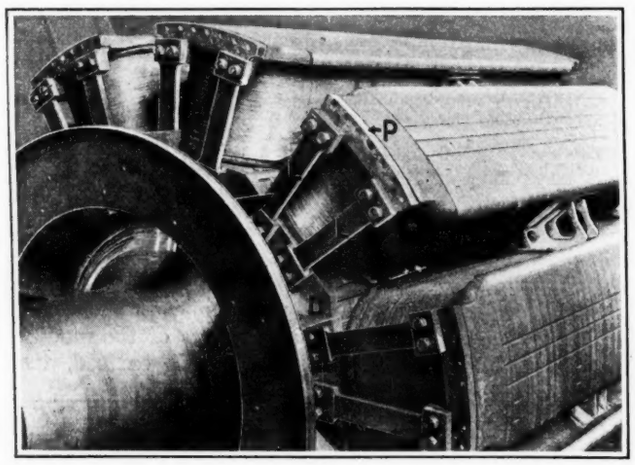


Fig. 3—Rotor for 15,000-kva. synchronous condenser

derived from the power input to this motor. Where this method is impracticable and attempts are made to measure the losses by means of wattmeters and transformers, the results are usually misleading, even where special instruments and transformers with phase-angle correction are used, as small errors are greatly magnified owing to the high ratios of transformation inherent to low power-factor tests. A test of this kind will also show that the power input to the modifier is not constant but may fluctuate. This may be seen from Fig. 5, which is a graphic record of the power input to a 15,000-kva. modifier when operated no-load at rated voltage and 100 per cent power factor. Special current transformers were provided for this test and power-input records obtained covering a considerable length of time. This curve shows that the power input fluctuated between 243 and 138 kw. These power fluctuations were due to variations in the impressed voltage and frequency combined with the rotor oscillations set up by pulsations in the power required to overcome the rotor windage. The latter, for high-speed machines constitutes an appreciable percentage of the total losses. For these reasons the modifier losses are commonly determined from its individual losses measured with the aid of a calibrated driving motor prior to its shipment.

After installation, the modifier losses for inclosed machines may be determined from the volume and temperature increase of its ventilating air. This method is based on the assumption that at constant machine temperature its losses equal the heat carried off in its ventilating air plus the heat it radiates to the surrounding air. The value of this method depends upon the accuracy of the air measurements. By adding the calculated bearing losses to the losses derived from the air measurements, accurate results are generally obtained. The heat radiated from the machine to the surrounding air is almost negligible when compact high-speed machines with forced ventilation are involved. The foregoing method was tried in connection with the field tests on the 15,000-kva. modifier previously mentioned, and its full-load losses were determined as 310 kw. The corresponding losses determined from factory test with a calibrated driving motor was 318 kilowatts. The 8 kw. difference between the two test results covers inaccuracies in measurements combined with the heat radiated from the machine to the surrounding air.

The individual losses in this 15,000-kva. machine for full load were as follows:

	Kilowatts
Core loss	105
Windage and friction	85
Stator I^2R + stray	78
Rotor excitation	50
Total loss	318

In the following table are given the full-load losses that may be expected for 60-cycle modifiers of ratings varying between 1,000 and 15,000 kilovolt-amperes:

Rating in Kw.	Losses	Speed in R.p.m.
1,000	45	1,200
2,000	72	900
3,000	94	900
5,000	125	900
10,000	248	720
15,000	335	720

The starting of the phase modifier is generally done either as an induction motor, as a synchronous motor, or by means of a separate driving motor.

When the first method is used, a polyphase alternating current of a potential lower than the one for which the machine is designed is applied to its stator terminals. The inter-action between the resultant rotating armature field and the rotor windings results in the torque that starts the rotor.

The current inrush to the modifier decreases with the starting voltage, which for that reason generally

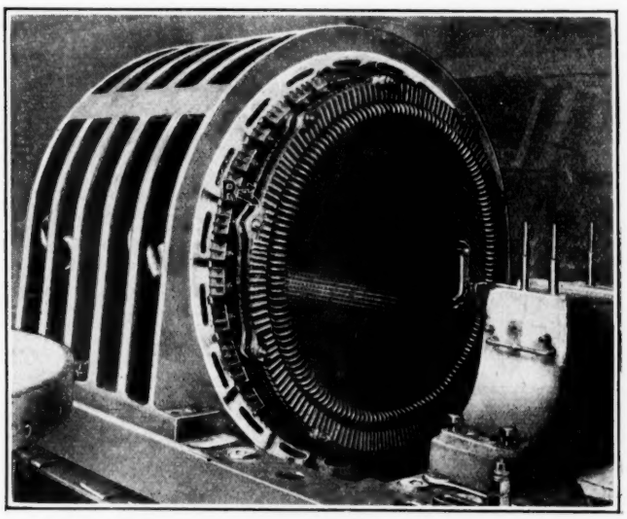


Fig. 4—Stator for 15,000-kva. synchronous condenser

is reduced to the value giving sufficient torque to overcome the static bearing friction. If the torque developed on the starting tap is sufficient to bring the rotor within 5 or 6 per cent of synchronism, it can be pulled into step by applying excitation. If this speed is not reached, the starting voltage must be increased before synchronism can be attained.

During the starting period the field circuit may be either open or short-circuited. With the field circuit open and a high ratio of transformation between the rotor and stator windings, a high voltage will be induced in the field circuit which may cause insulation failure. With the field short-circuited this danger is eliminated, but a single phase current is induced in the field circuit, which tends to make the rotor stick at a speed between 50 and 80 per cent of synchronism. These effects, however, can be overcome by the proper design of the squirrel-cage winding. For these reasons

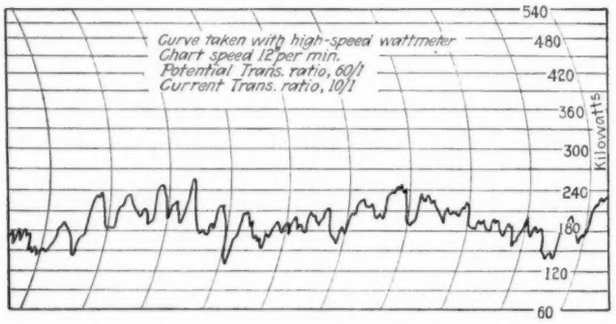


Fig. 5—Record of current taken by machine, Figs. 3 and 4, at unity power-factor operation

it is considered advantageous to start the modifier with its fields short-circuited either directly or through a suitable resistance.

The starting voltage is usually obtained from special starting transformers or taps on the main transformers. By providing a small auxiliary oil pump, an oil film can be established in the bearing prior to starting the machine from rest, which greatly reduces the starting torque required and permits the use of low starting

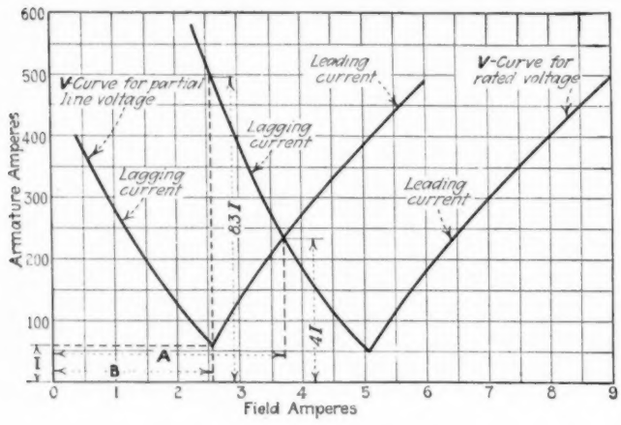


Fig. 6—Shows effect of adjusting field current when changing from low- to full-voltage taps

voltages. Further, by providing a number of starting taps and successively increasing the starting voltage until synchronism is attained, the starting kva. required can be reduced to 25 per cent or less of the rating. To minimize disturbances the machine should, wherever practicable, be excited and synchronized on the starting tap, and its field excitation adjusted to the full-voltage condition before it is connected to the line.

The importance of the foregoing is shown in Fig. 6, which shows the "V" curves corresponding to one-half and full terminal voltage of a synchronous motor. For the excitation *B* the current input is *I* and a minimum for the starting voltage; with unchanged excitation this current increases to 8.3 *I* when full voltage is applied. By adjusting the excitation to a value *A* before full voltage is applied, the stator current remains the same for one-half and full voltage. This assumes, however, that the time required for connecting the machine from starting to running voltage is short enough to prevent an appreciable angle of lag to develop between the stator and rotor fields. Fig. 7 is a graphic record of the power required to start and pull into synchronism a 15,000-kva. 720-r.p.m. modifier which is provided with forced lubrication during the starting period. The modifier is brought into synchronism on the starting tap and connected to the line in 1¼ min. If desirable, this power input could be reduced by reducing the starting voltage of the modifier, which would increase the time required for its acceleration. The induction-motor method of starting lends itself readily to automatic starting and synchronizing with a comparatively simple switching and relay arrangement.

The second starting method, which consists in bringing the condenser up to speed as a synchronous motor, causes no line disturbances but does require an auxiliary alternator and can be used only where such is available. With the armature windings of the modifier and alternator coupled and their fields excited, they

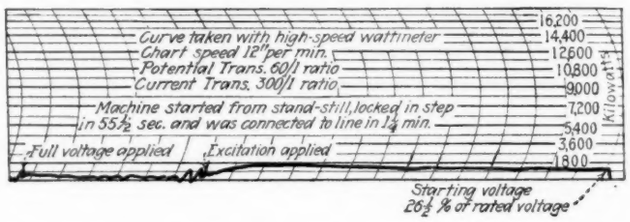


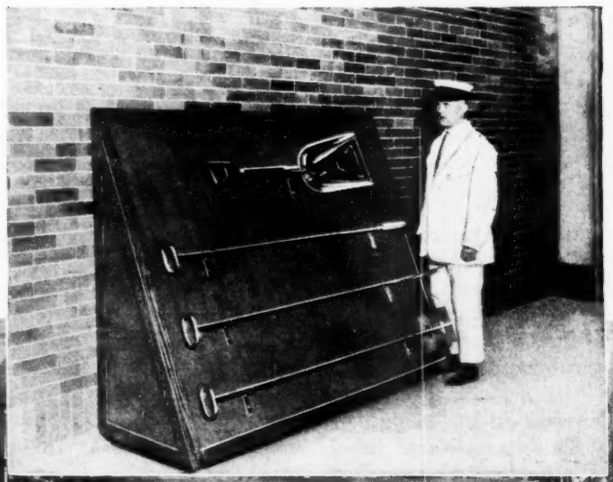
Fig. 7—Input to machine, Figs. 3 and 4, during starting

are brought up to speed together and synchronized with the power system before the connection at the phase modifier.

Finally, the method of starting a modifier with the aid of a starting motor is resorted to in installations where no suitable auxiliary generator is available and where the starting current must be limited to a value that is lower than that obtainable by starting the machine as an induction motor. Where direct-current power is available, the use of a direct-current starting motor with speed control permits the synchronizing of the modifier before it is connected to the system. Where an alternating-current starting motor is used, it should preferably have at least two poles less than the modifier to permit the latter to be synchronized before it is connected to the system. If the driving motor has the same number of poles as the modifier, synchronism cannot be reached on account of the motor's slip, and it becomes necessary to connect the modifier to the power system through reactance coils.

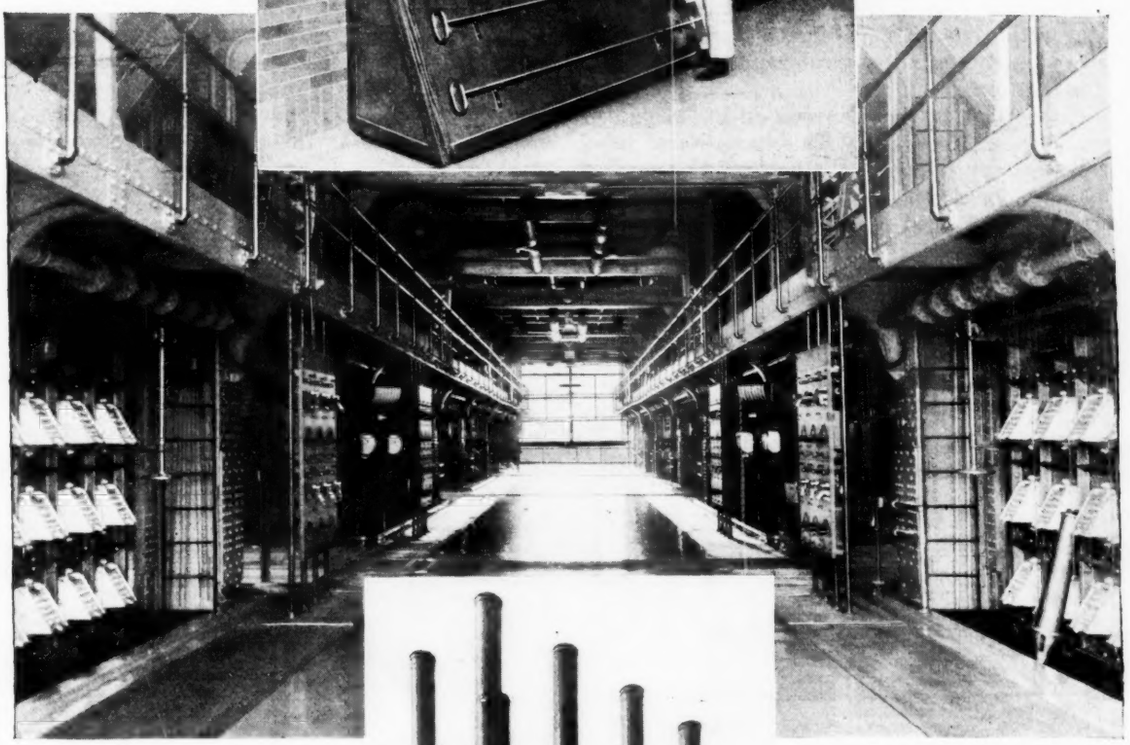
The real criterion as to where the purge connection should leave an ammonia condenser, is not a matter of top or bottom. The foreign gases should be withdrawn from the point in the condensing system where the temperature of the gases and vapors is lowest. This may not be where the water is coldest, and in exceptional cases it may not be in the condenser at all, but in the ammonia receiver or in some other place.

Dirt is Taboo in Henry Ford's River Rouge Power Plant



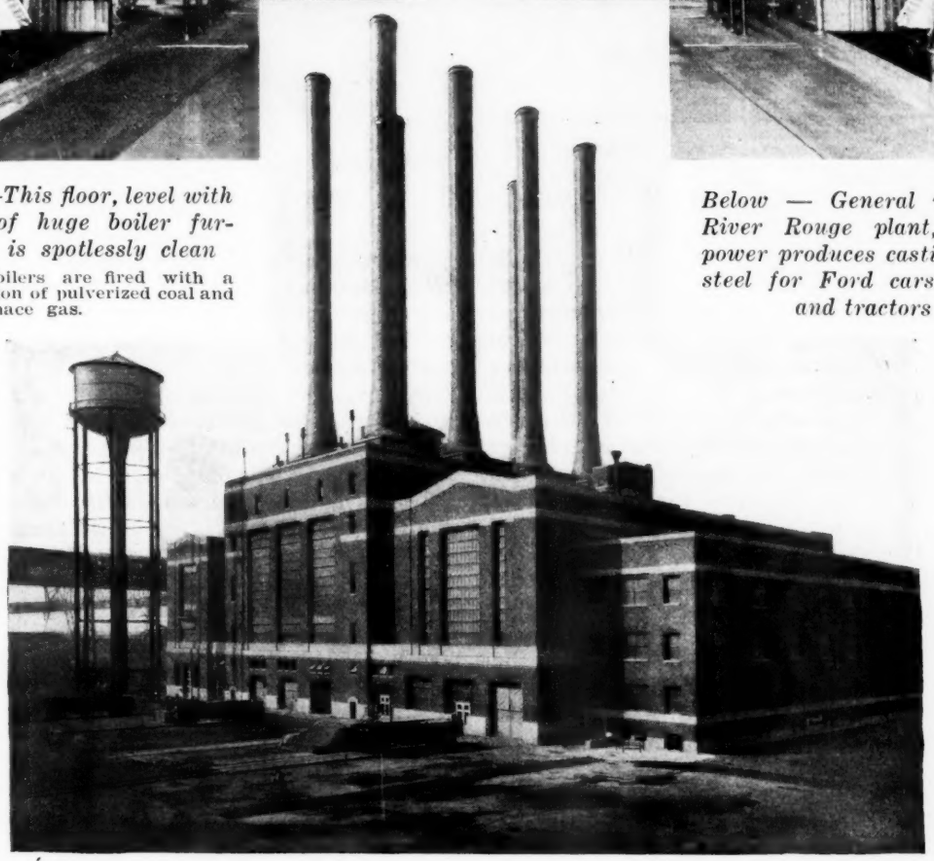
Left—The sweating fireman of old is replaced by a button-pushing boiler-room attendant in white duck

For old-time's sake the former firing tools have been nickel-plated and placed on exhibition.



Above—This floor, level with center of huge boiler furnaces, is spotlessly clean

The boilers are fired with a combination of pulverized coal and blast-furnace gas.



Below — General view of River Rouge plant, whose power produces castings and steel for Ford cars, trucks and tractors

Characteristics of Hvid-Engine Fuel Cup

By A. J. NICHOLAS

ONE of the most interesting fuel-ignition devices for oil engines is the Hvid fuel cup. Authorities seemingly do not agree as to whether this engine belongs to the full Diesel or semi-Diesel type, but a study of the action of the cups shows that the engine is, at least, not a Diesel, although depending upon compression for ignition.

The Hvid form of ignition depends on the design of a steel cup, as shown in Fig. 8. This has several small holes, parallel to each other, at the bottom, the number and size of holes depending upon the size of engine and the character of fuel used. The engine employs high compression pressures, ranging from 425 to 475 lb. per sq.in., equivalent to the Diesel compression, and ignition of the fuel is brought about by the generated heat of the compression of the air change. Typical arrangements of the cup in the combustion chamber found on two makes of engines is shown in Figs. 1 and 2.

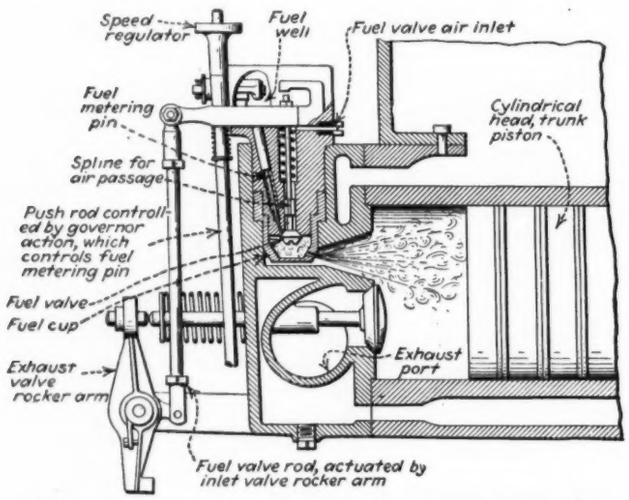

Speed regulator
Fuel well
Fuel valve air inlet
Fuel metering pin
Spline for air passage
Cylindrical head, trunk piston
Push rod controlled by governor action, which controls fuel metering pin
Fuel valve
Fuel cup
Exhaust port
Exhaust valve rocker arm
Fuel valve rod, actuated by inlet valve rocker arm

Fig. 1—Combustion chamber of small Hvid Engine

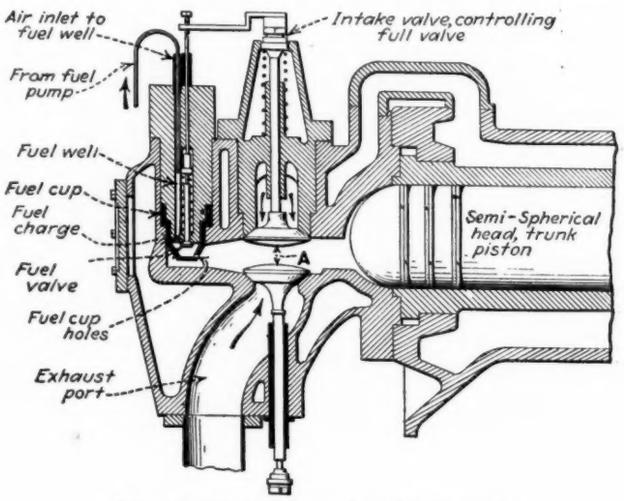


Fig. 2—Design found in large units

The fuel generally used is kerosene or fuel oil. The cycle of events may be illustrated with the use of Fig. 2. On the suction stroke of the engine the inlet valve allows atmospheric air to flow into the cylinder. At the same time the fuel valve in the cup is opened. A measured amount of fuel, which rests on top of the valve, drops into the cup. This fuel is pumped into the fuel valve chamber by a pump whose stroke is varied by the action of the governor. The chamber, which holds the fuel, is open to the atmosphere, and when the fuel valve opens some air is drawn in through the fuel chamber into the cup. The lighter hydrocarbons of the fuel coming in contact with the hot cup instantly vaporize, some of which pass on into the cylinder. Upon compression the temperature rises and ignites this lean mixture. As the piston approaches its maximum compression, the flame is propagated back into the cup through the small holes. Since the compression temperature is in the neighborhood of 900 to 1,000 deg., part of the fuel combines with the small volume of air in the cup and the pressure rises to about 700 lb. per sq.in. This high pressure ejects the solid fuel through the small holes into the cylinder, some atomization of the fuel occurring in this ejection. The fuel coming in contact with the hot charge in the cylinder combustion space, will burn as the piston recedes on its working stroke.

For kerosene and fuel oils it is a well-known fact that the ignition temperatures are far below that temperature resulting from the compression in this engine. If the kerosene or fuel oil were exposed to this temperature, preignition would occur long before the piston reached its maximum compression. It is evident that the cup performs two functions: (1) Delays, and therefore, times the ignition of the fuel until full compression is attained in the engine; (2) atomizes the fuel. Both of these are attained through the small holes at the bottom of the cup.

The advantages claimed for the engine are: (1) Mechanical simplicity; (2) low fuel consumption at all loads, being on a par with the Diesel; (3) ability to start and run on any oil that will flow through a pipe; (4) low water-jacket loss; (5) no lubrication difficulties; (6) constant compression; (7) remarkable torque characteristics; (8) absence of all electrical devices, hot bulbs, and torches for ignition purposes; (9) absence of all carbureting mechanism; (10) no carbon deposits; (11) production in units from 1½ to 60 hp.; (12) low initial cost, being able to compete with gasoline engines of the same size.

A study of the list will show that with the exception of items 1, 11 and 12, each is equally applicable to the

Diesel engine, with better advantages in the case of items 2 and 7. However, to make a fair comparison between a Diesel engine and any other type, it is necessary to do so on the study of design of combustion chamber, of the indicator diagrams produced and the method of governing.

In the Diesel the combustion chamber has no pockets, therefore has no stratification of air and dead gases on the compression stroke. Pure air is compressed at all times, which gives for the Diesel the best mathematical air-cycle thermal efficiency. The admission of the fuel is fairly well regulated, and burning of the fuel takes

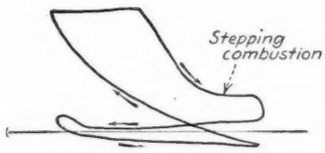


Fig. 3

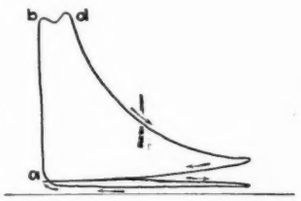


Fig. 6

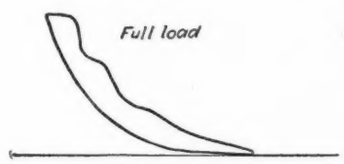


Fig. 4

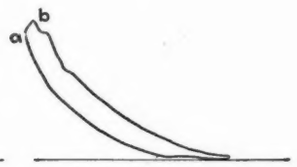


Fig. 7

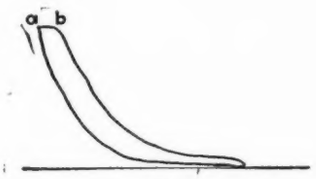


Fig. 5

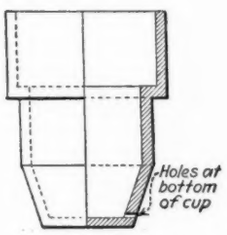


Fig. 8

Figs. 3 to 7—Indicator Diagrams showing combustion
Fig. 8—Design of Hvid cup

place at nearly constant pressure. The fuel charge is finely atomized by using compressed air for fuel injection.

Design of Combustion Chambers

Examination of combustion chambers in Figs. 1 and 2 shows that they are designed along the well-known principles employed in semi-Diesel type of engines. The cup is in a pocket and stratification will occur. Burnt gases remain in it after the exhaust stroke is complete, and on the suction stroke these are drawn next to the piston head. When the suction stroke is completed, a clean charge is found in the pocket, with dead gases at the piston head. The pocket should be of small cross-section with provision for rapid velocities of gases, in which case the exhaust gases are swept out by the returning piston, and in turn the inlet charge removes any burnt gases toward the piston head, leaving a pure charge in the pocket, where the primary burning takes place. The initial combustion in the cup will dilute somewhat the charge in the pocket, and affect the combustion. In the design of Fig. 2, the valves are so arranged as to produce a Venturi effect shown at *A*, thus forcing the burning charge at an increased velocity into the cylinder, producing turbulence, hence better combustion. Such a design of head is better than that shown in Fig. 1.

A comparison on the indicator diagram basis will show that in the Diesel, Fig. 5, combustion is practically uniform. This is due to good atomization and a properly designed nozzle having a well-regulated air blast. In Fig. 4 the combustion takes place in the form of steps or waves. This wave form of combustion is also evident in Fig. 7, and since it produces excessive bearing pressures, a sturdy design is necessary. Such combustion would cause a great water-jacket loss and give a lower thermal efficiency. Fig. 6 shows no such wave characteristics. Explosion of the charge took place at *a*, raising the pressure to *b;* combustion occurred along *bd*, which was not uniform. It is probable that combustion in the cup was complete at *d*. The injection of the fuel no doubt lasted from *b* to *d*. Undoubtedly, the waves in Figs. 4 and 7 were due to imperfect atomization of the fuel. In Fig. 7 the injection of the fuel was very rapid, with the consequent rise in temperature and pressure to *b*.

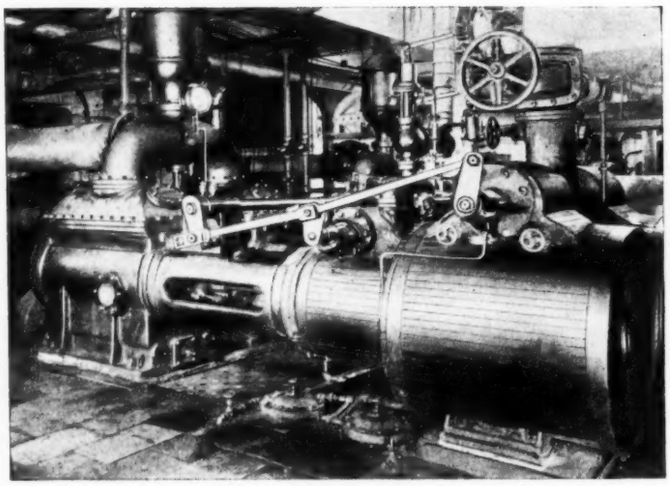
Qualitative Governing

The governing in the case of the full Diesel and the Hvid, is the same and is of the qualitative type. The air drawn in is constant, the fuel being varied. This type of governing gives good thermal efficiency at low loads. At overload, however, it is wasteful in fuel, consequently the range of governing is not as great as in the other types. The tendency of the Hvid to smoke at overloads is marked.

The Hvid type calls for a sturdy design to take care of any erratic operations in the cup that might produce explosive effects. Nevertheless this principle works well in comparison with the class of engines with which it is designed to compete. It is doubtful if its success would be so marked in competition with the Diesel.

The best evaporation to be expected from bituminous coal is about 10 lb. of water per pound of the best Pocahontas coal. Hand firing will seldom show over 9.5 lb. while stokers may go up to 10 lb. per pound of coal. Using this figure of 10 lb. per pound of coal and the average results of several tests, 15 lb. per pound of oil, it is seen that the relative value of oil and coal per pound is 1.5 to 1. With an oil weight of 7.65 lb. per gallon and 42 gal. per barrel, a barrel of oil (322 lb.) is equivalent to 483 lb. of coal, or a ton of the best coal, when handled to give the best results, is equivalent in evaporating results to approximately 4 bbl. of oil, or a ton of coal is equivalent to 174 gal. of oil.

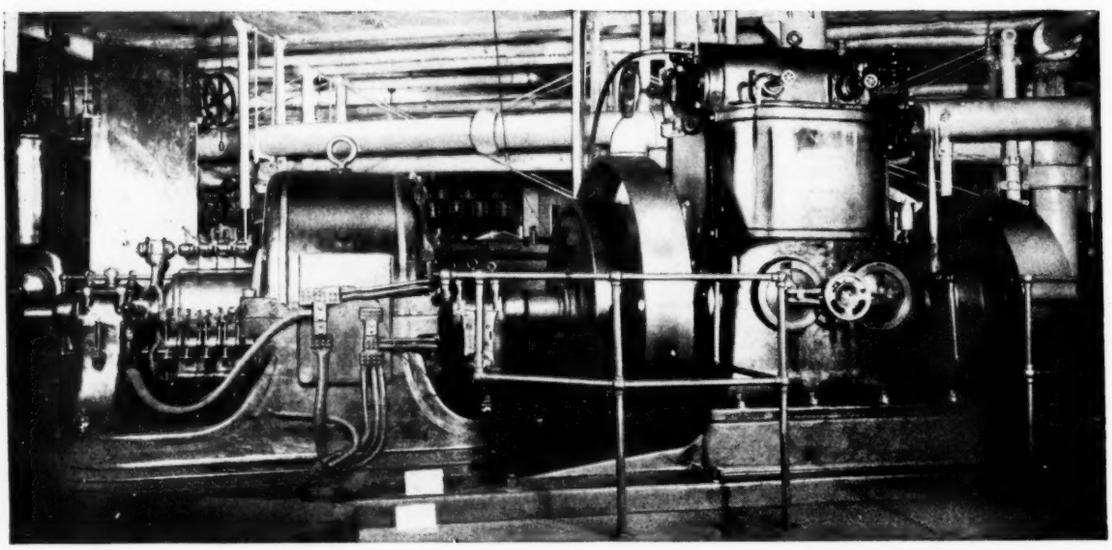
The presence of air in a refrigerating system may be the result of a leakage into the system at a time when a vacuum was formed in one part or another, or the air may have remained from the time when the system was filled with ammonia. When repairs are to be made, the part of the system to be repaired is pumped to a vacuum to remove the ammonia before it is opened. In a similar way the air in this part is exhausted before ammonia is admitted. A perfect vacuum is impossible, and this process always admits some air to the system, though it may be only a small amount if care is exercised and the vacuum is good.



Old Engines and Pumps Still Operate in New York

Left—This 18-in. and 29-in. by 18-in. direct-acting, duplex, compound Worthington pump, installed in 1893, still serves hydraulic elevators in the old Produce Exchange in New York City near the "Battery"

Behind it may be seen the air chamber of a similar pump installed in 1884.

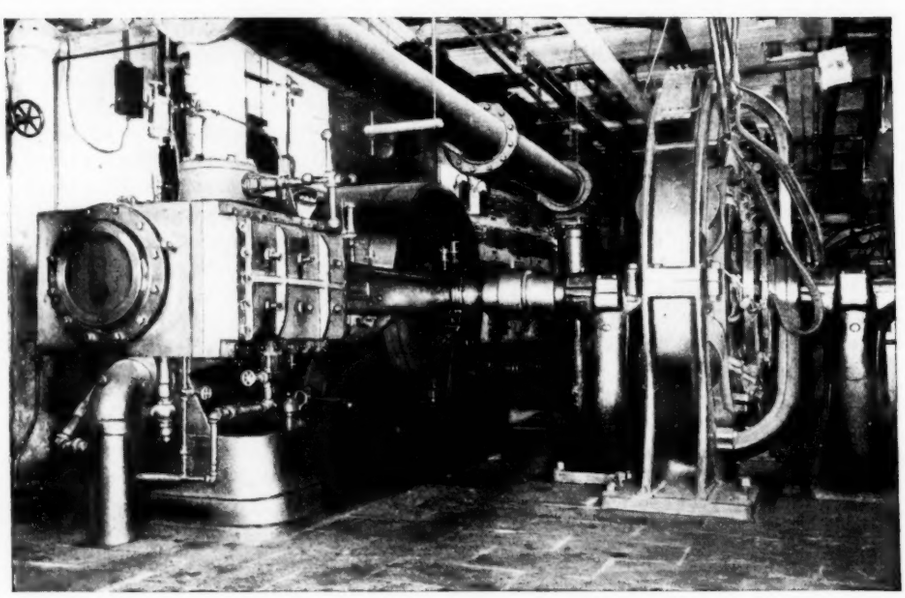


Above—In the engine room of the Postal Telegraph Building are five of these old Westinghouse vertical, single-acting, 75-kw. generating sets

The unit shown, which was exhibited at the Chicago World's Fair in 1893, is still operated during the heating season.

Right—Most interesting of all is this Sweet "Straight-Line" engine, installed about 40 years ago at the Produce Exchange —and still running

Note absence of common bedplate for unit. The 100-kw. 125-volt generator has eight poles and a radial commutator.



Advantages of Feed-Water Heating By Stage Bleeding

By R. W. BOOZE

IT IS now becoming common practice, even in plants of moderate size, to heat the feed water by steam extracted from various bleeder nozzles in the main turbine, using motor drive for the auxiliaries. Formerly, it was customary to heat the feed water with the exhaust from the steam-driven auxiliaries operating against a constant back pressure near atmospheric. The contention was that the efficiency of this scheme could not be improved upon because all the heat in the steam so used was recovered in the feed water. While it is true that all the heat in the exhaust steam is recovered, it is not necessarily true that the heat supplied to these auxiliaries is utilized most effectively.

A detailed theoretical explanation of the advantages

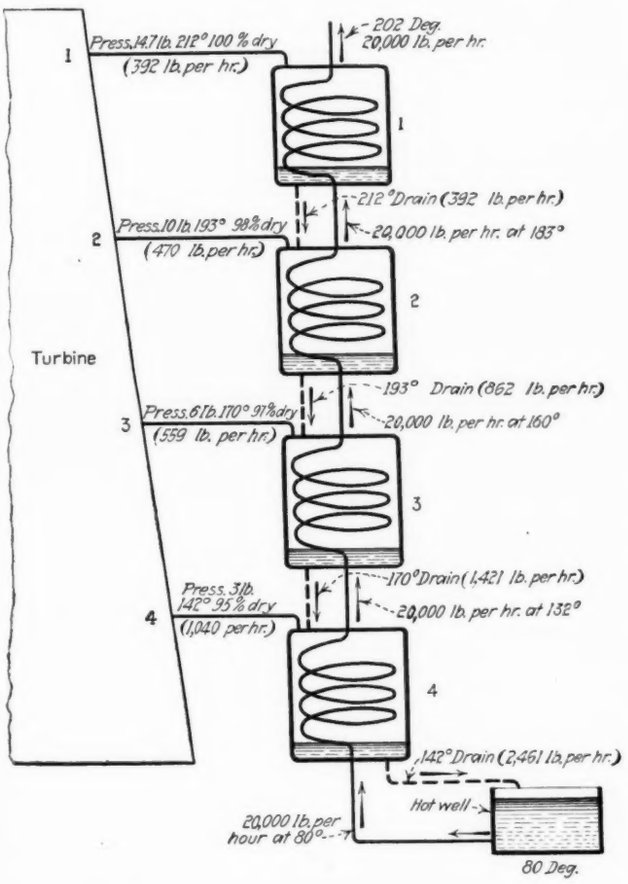

Press. 14.7 lb. 212° 100 % dry
(392 lb. per hr.)
202 Deg.
20,000 lb. per hr.
1
212° Drain (392 lb. per hr.)
Press. 10 lb. 193° 98% dry
(470 lb. per hr.)
20,000 lb. per hr. at 183°
2
Turbine
193° Drain (862 lb. per hr.)
Press. 6 lb. 170° 91% dry
(559 lb. per hr.)
20,000 lb. per hr. at 160°
3
170° Drain (1,421 lb. per hr.)
Press. 3 lb.
142° 95% dry
(1,040 per hr.)
20,000 lb. per hr. at 132°
4
142° Drain (2,461 lb. per hr.)
Hot well
20,000 lb. per hour at 80°
80 Deg.

Fig. 1—Feed water heated from 80 deg. F. to 202 deg. by steam bled from four stages

of bleeder heating is somewhat involved, and it is thought that the following simplified explanation will give the reader a good idea of the essential principles involved.

It will be assumed that 20,000 lb. of feed water is heated from the hotwell temperature of 80 deg. F. to 202 deg., with an auxiliary-exhaust feed-heating system in one case and a four-stage bleeder-heating system in the other. The results obtainable by the two systems will be compared.

To simplify calculations, closed heaters are assumed in each case with a final temperature difference, between the water leaving the heater and entering steam, of 10

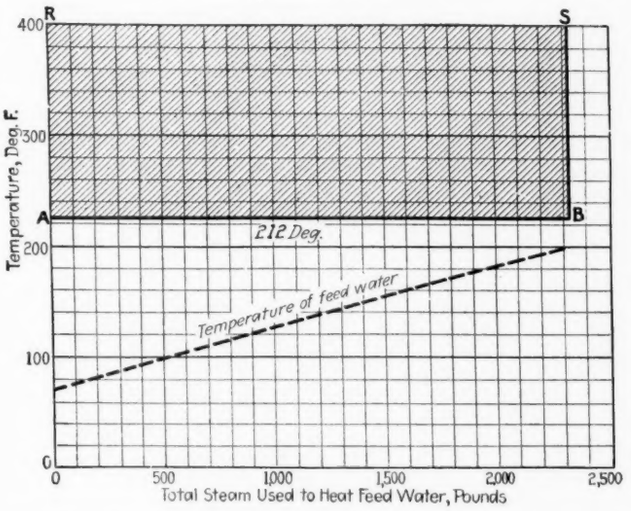


Fig. 2—Area between dotted line and AB represents additional power that might be obtained from feed heating steam

deg. F. The final drains in each case are cooled down to a final temperature of 142 deg. F. The steam conditions in the auxiliary exhaust and at each bleeder point are as follows:

Auxiliary exhaust	14.7 lb. per sq.in., abs., 212 deg. F., 100 per cent dry
First bleeder point.....	14.7 lb. per sq.in., abs., 212 deg. F., 100 per cent dry
Second bleeder point.....	10 lb. per sq. in., abs., 193 deg. F., 98 per cent dry.
Third bleeder point.....	6 lb. per sq.in., abs., 170 deg. F., 97 per cent dry.
Fourth bleeder point.....	3 lb. per sq.in., abs., 141 deg. F., 95 per cent dry.

With these assumptions the diagram shown in Fig. 1 for the installation with bleeder heating may be prepared with all the indicated data except that shown in parentheses.

Starting with the first bleeder point, it is evident that enough heat must be supplied to raise the temperature of 20,000 lb. (per hour) 202 — 183 = 19 deg. This will require 20,000 × 19 = 380,000 B.t.u. Dividing this by 970.4, the latent heat of steam at 14.7 lb. absolute gives 392 lb. of steam per hour from the first bleeding point.

The condensation of this weight of bled steam will give the same weight of drip to be piped to the second

heater. The heat supplied to the feed water in this heater is 20,000 × (183 — 160) = 460,000 B.t.u. The drain from the previous heater, in cooling from 212 to 193 deg. will give up 392 × (212 — 193) = 7,000 B.t.u.[1] This leaves 460,000 — 7,000 = 453,000 B.t.u. to be supplied by bled steam. The heat given up per pound will be 0.98 × 982 = 962 B.t.u., so the steam bled per hour from the second stage will be 453,000 ÷ 962 = 470 lb.

The drain from the second heater to the third must

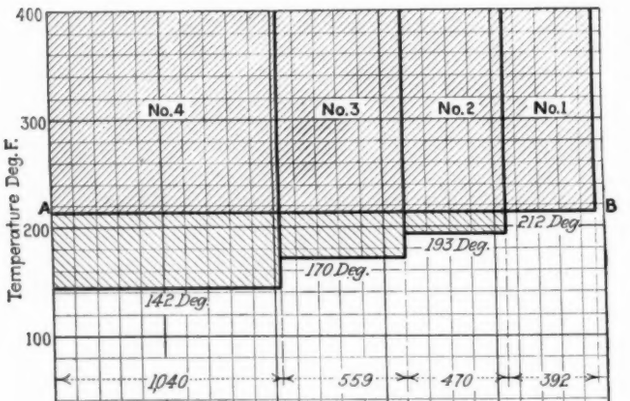


Fig. 5—Shaded area below AB represents additional power development from bled steam

be the sum of the steam bled from the first two points, or 392 + 470 = 862 lb. The corresponding figures shown for the third and fourth heaters are obtained in the same way.

In the case where the feed water is heated by auxiliary exhaust, the total heat supplied to the feed water is

(202 — 80) × 20,000 = 2,440,000 B.t.u.

The heat given up by each pound of steam is 1,150.4 — (142 — 32) = 1,040.4 B.t.u. Therefore the weight of steam required for feed heating is 2,440,000 ÷ 1,040.4 = 2,340 lb.

The corresponding total bled steam is 392 + 470 + 559 + 1040 = 2,461 lb., this being slightly higher than the other because much of the heating is done by wet steam at lower pressures. The difference is not of material importance.

The results are shown graphically in Figs. 2 and 3, in which the ordinates represent Fahrenheit temperatures and the abscissas total weights of steam used for feed-water heating.

The shaded areas in each figure are approximately proportional to the heat that is extracted in performing work from the steam ultimately used to heat feed water. The shaded area below the line *AB* in Fig. 3 is approximately proportional to the increased amount of heat that is available for performing work in the bleeder heating system. That is, in each case the same amount of feed water is heated through the same range of temperature, but in the bleeder heating system the steam used for heating the feed water does an additional amount of work which is approximately proportional to the shaded area below the line *AB*. This area may be increased to its maximum size by the use of a large number of bleeder stages.

[1]Computations are carried only to even thousands of B.t.u.

In the study of these figures it is to be noted that the areas do not exactly represent quantities of heat, particularly above the line *AB*. The areas above this line in each figure are of value only for comparison. Below the line *AB*, however, the shaded areas approximate the heat available for performing work before being used for heating feed water.

In addition to the advantage of the bleeder heating system which has just been described, namely, that of more heat being available for conversion into mechanical energy, there is another advantage. This is that the heat converted in expanding from the line *RS* down to the line *AB* will be converted more efficiently in the main unit of the bleeder system than in the small separate units of the auxiliary system. That is, more work will be obtained from one pound of steam expanding through a certain temperature range in the main unit than will be obtained from one pound of steam expanding through the same temperature range in a small auxiliary driving unit.

The kilowatt-hours obtained from the steam used for feed heating per pound of feed water heated through a given temperature range is the only figure that indicates exactly the relative efficiencies of two systems of feed-water heating. It is evident that this figure will be considerably greater in the case of the bleeder heating system than in the case of the auxiliary-exhaust heating system for the two reasons that have been described.

The prism binocular field glass so popular with army officers, tourists and scientists is, in effect, a pair of telescopes coiled up like bugles with reflecting prisms to shoot the light around the corners. In their article "Increasing Financial Efficiency by Simplification of Design," in the May 19 issue, Vehling and Crawford did the same thing for the boiler. They recommended a design in which the gases passing up through the boiler reversed 180 deg. and passed straight down through economizer and fan to an air-jacketed breeching. The result was a very compact construction in which the height saved corresponded to the length saved in the binoculars.

Priming and foaming are so closely related that the words themselves are often confused, although they do not mean the same thing. Priming means the carrying of water over into the steam pipes. The term does not, however, include the one or two per cent of permissible moisture that is found in the form of fine mist or fog in the steam. Foaming, which is one of the causes of priming, means the piling up of bubbles on top of one another, owing to a certain "stickiness" in the water. This stickiness, or increase in surface tension, may be due either to finely divided solid matter or to dissolved salts.

How long is it since you checked up on the condition of the non-return valves when taking a boiler out of service or by shutting off the draft and noting the time necessary for the pressure to fall below the header pressure and comparing this with previous records. This test may show a valve to be inoperative and in need of overhauling.

Sodium compounds are all highly soluble and never form scale as such. When present in large quantities, they may cause or aggravate priming.

Influence of Lubrication on Machine Design

ONE of the striking differences between engines of today and those of twenty-five years ago is in the frame design. Formerly, the aim of the manufacturer was to create a machine whose every part was open to inspection. Even if the engine was to be installed in a dusty locality, accessibility was deemed imperative. As long as lubrication was obtained through sight-feed oilers or by compression cups, the engineer was quite justified in hourly fueling the various pins and bearings, and since bearing pressures were low such lubrication methods were quite permissible.

Of late years high steam pressures have resulted in bearing and pin loads such that the oil film tends to be squeezed away from the wearing surfaces and the amount of lubricating oil supplied to the bearing has been increased many fold. As a further precaution against bearing seizure the pressure system is largely adopted as a means of maintaining an oil film between journal and bearing. It is obvious that such lubricating methods on the old-time open-frame engine would have converted the engine room into an oil pool.

Closed frames have become a necessity and the fact that all the oil-engine and compressor builders are now using enclosed box frames is due to the lubrication problem. Steam-engine builders have generally adopted the closed frame, and there is a strong drift toward the readvent of the vertical box-frame design, at least two unaflow builders having adopted this type.

Building the New Steam Tables

THE commercial interest in high steam pressures and temperatures has grown so rapidly that the accumulation of scientific data has lagged behind the immediate needs of designers. The data in the published tables of steam properties, while accurate in the lower ranges of temperature and pressure, are little more than good guesses in the higher ranges.

According to present indications this situation will be corrected within the next two or three years. Some work of high quality, although not reaching as far as could be desired into the high-pressure region, has recently been completed by Knoblauch and other European investigators. In this country progress is being made in an extensive program of steam research at Harvard, Massachusetts Institute of Technology and the Bureau of Standards. In England Professor Callendar, backed by the powerful "B.E.A.M.A.," has been making an independent investigation along original lines, as outlined by I. V. Robinson in the July 28 issue. Taken together, these numerous investigations, each made with the greatest care, will permit numerous cross checks, practically eliminating the possibility of any serious error in the final published results.

The need for more reliable steam tables is so pressing that some of the large manufacturers of turbines and other steam equipment are already using the data so far made available to compute tables and diagrams for their own use. In view of the fact that a steam turbine may easily consume its own cost in steam each year the expense of such efforts to anticipate final publication of the results is doubtless amply worth while.

Contradictory Operating Practices

CONDITIONS under which a power plant is to operate will to a large degree influence its design and the type of equipment chosen. It is well recognized that a plant that will be best suited for a combined power and heating load, may not be well adapted to conditions where the power load predominates to a large extent or where there is no heating load except during the winter months. The type of equipment that might be best suited for a large plant in the hands of high-class engineering talent, would not be suitable in a small plant operated by less-skilled attendants.

The diversity of conditions under which plants operate can well account for the wide difference in their design and operating practices. Where two plants operate under practically the same conditions in the same locality, it becomes difficult to reconcile the wide difference in practice that may be found. As an actual case in point the owner of one of two plants apparently finds it economical to shut down completely and purchase all steam and power. The owner of the other plant continues to operate and in so doing supplies the building power and heating load at about fifteen per cent less cost than the power alone can be purchased for. If power and steam could be bought at a lower rate in one case than in the other, or if the plant were already in operation in one building and in the other a new plant had to be built, there might be some justification for the two radically different practices to serve the same kind of load. The answer to this paradox can apparently only be found in two reasons—first, the design of the plants and second, the way they are operated, or a combination of both.

Where there is an excess of exhaust steam in a non-condensing plant, all auxiliaries should be driven electrically and the power generated in units of a type that will give a minimum of exhaust steam. If auxiliary power is supplied by steam-driven equipment that requires four or five times the amount of steam necessary to do the same work in the main units, the cost of power is going to be materially increased if all the exhaust steam cannot be absorbed in the heating system. By driving the auxiliaries electrically, all the power is produced at the best efficiency, which will result in a minimum steam consumption. There are other factors of design that influence the cost of producing

power, but the foregoing is one that is frequently overlooked.

It does not make any difference how well suited a plant may be to a given load, it remains with the operating engineers to get results. Dirty boilers with leaky settings, improper firing, leaky steam joints and uninsulated steam-heating surfaces, leaky and improperly set valves on the engines, can easily increase the coal consumption two or three times over that required if the plant were properly operated. The operating engineer who is interested in holding his job and keeping his plant running may well give careful attention to see that his plant is of a design best adapted to the load and that everything is done to operate it most efficiently.

Economy of High-Quality Internal-Combustion Engines

THERE are over two hundred million horsepower of internal-combustion engines in use in this country, most of which make use of petroleum fuels. Of these less than a million horsepower can be said to be operating at anywhere near the highest possible efficiency. Power from the balance is procured with a fuel consumption ranging from twice to ten times the amount actually needed if the engine designs were not woefully lacking in essential particulars. This, of course, covers automotive as well as stationary engines.

If these statements be true, and they are verified by every-day operating results, manufacturers of internal combustion engines owe it to the country to face about and build economical machines. The gasoline consumption of the automobile engine when viewed on a horsepower basis is startling and is endured only because the fuel is apparently cheap. On a basis of thirty thousand miles per car life, about two thousand gallons of gasoline is consumed by each automobile. Increasing its engine efficiency would reduce this to one thousand gallons, a saving of two hundred and fifty dollars per car. Inasmuch as the average automobile engine costs less than this to manufacture, it seems that the automobile manufacturer would be justified in materially increasing the manufacturing cost of the engine in order to obtain the better efficiency.

Somewhat the same conditions exist in power-plant engines. Thousands of oil engines using a pound of oil per horsepower-hour have been purchased simply because the first cost was less than that of a more efficient oil engine. By an increase of a few dollars per horsepower an engine using less than one-half a pound of oil per horsepower-hour could have been obtained.

This condition is due largely to a lack of appreciation of the relatively low price of high-quality products. The maker of a cheap article tries to sell it at a price as high as is possible, and owing to the appeal of cheap prices, the purchaser passes by the high-quality article to save a few dollars through the purchase of the cheap article at a somewhat lower price. Consequently, the sale of poor-quality products is always greater than that of the better grades and profits are much greater. This marketing condition forces the builder of a high-quality machine to sell it at as low a price as is possible in order to compete. One is quite safe in assuming that there is less profit in the high-quality economical machines. Rising fuel costs demand the elimination of "oil eaters," and a purchaser is suffering a large financial loss by considering first cost only and by ignoring the quality of the product which reflects in the economy of operation.

The Turbine as a Reducing Valve

THE best steam-electric stations deliver as power only about one-fifth of the energy contained in the fuel. A good steam-heating plant, however, will transform around two-thirds of the fuel energy into that for heating. A combined electric and heating plant operating under conditions in which all the exhaust steam is utilized, is able to turn fuel energy into power much more economically than the station producing electricity alone. Of course, where large losses due to load variation, waste of low-pressure steam, etc., are to be allowed for, actual station performance will suffer accordingly.

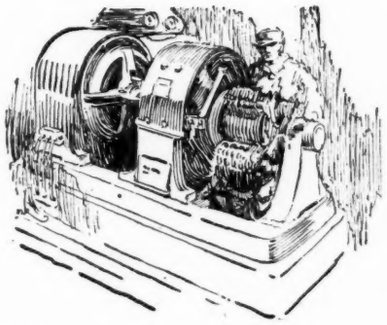
Although a turbine or engine utilized as a reducing valve to convert heat units of high-pressure steam into those of low-pressure steam and electrical energy, makes possible a desirable form of combined cycle, yet another benefit is made possible on account of the fact that internal prime-mover losses are not necessarily detrimental. Turbine disks and blades produce considerable friction revolving in an atmosphere of steam. Power thus taken from the rotating element is largely returned to the steam and reduces the moisture at the exhaust or increases the superheat. As actual heat units these, therefore, are available to the heating system, although for purposes of power production their loss may be immaterial.

A kilowatt-hour of electrical energy under favorable conditions is chargeable with generator losses and prime-mover external losses. Since steam passes through a turbine at high velocity, radiation is relatively low. As there is practically no contact between moving and stationary parts, friction is also almost a negligible quantity. External losses vary from about fifteen per cent in small to around three per cent for large turbines in terms of power at the coupling. A medium-sized unit with external losses of nine per cent and generator efficiency of ninety-five, would on this basis deliver a kilowatt-hour from about four thousand thermal units in the steam, assuming all the exhaust to be utilized. Correcting this value for the remaining station losses, favorable conditions should make possible one-half of a fuel heat unit available as power.

While hard to picture just now, next winter's demand for heat will roll around as surely as taxes and death. Last winter certain defects in the heating system called loudly for attention. Perhaps the time was inopportune for making needed repairs and replacements. Leaky traps, defective valves and "water hammering" piping may now be taking a vacation, but before many months have passed, they will find another opportunity to wear on the nerves and the pocketbook.

While the general tendency in power plants at the present time is to change from oil to coal owing to the extremely low price for bituminous coal, conditions in the anthracite field are causing metropolitan plants to burn oil if necessary. Oil prices, however, are too high to compete with the present market prices of coal.

Practical Ideas from Practical Men



WITH a view to stimulating engineers into the habit of recording for the benefit of brother engineers, unusual occurrences, how these were met and other practical expedients adopted in the operation of their plants, Power has decided to award two cash prizes each month during 1925. One of $25 for the best and another of $15 for the second best practical letter on plant operation or practical kinks received during the month. This is in addition to payment for the contribution at space rates. The winners for July will be announced next month.

Power is pleased to announce the awards of the judges for the first and second prize contributions received during June for this department in accordance with the terms of the contest as stated above.

The first prize of $25 goes to H. D. St. Martin, of Gramercy, La., for his article on "Facing Coil Connection Bosses in Vacuum Pans," in the July 14 issue.

The second prize of $15 goes to William J. Lapworth, of Pittsburg, Kan., for his article on "Steam-Valve Actuating Mechanism Simplified," in the July 28 issue.

The judges were: (Chairman) D. L. Fagnan, formerly refrigerating engineer, and more recently associated with the Smoot Engineering Corp., New York City; Willis Lawrence, mechanical engineer, Interborough Rapid Transit Co., New York City; and Norman N. King, chief engineer, Singer Bldg., New York City.

Determining the Safe Speed for Wood Pulleys

The trend at the present time appears to be toward higher pressures and higher speeds, but while an effort is made to meet these demands, some of the smaller details are overlooked. In the present case I refer to the safe rim speed for wood pulleys. I have always considered 300 r.p.m. a good speed for wood pulleys up to 36 in. in diameter, but a recent accident brings up the question, What is the safe speed?

I have never considered that the best quality of wood has a tensile strength of more than 3,500 lb. per sq.in. cross-section and when made into wood pulleys in which the pieces are dovetailed and glued together, the strength of the joints is a matter of conjecture. The so-called spokes are simply suitable pieces of wood running across the diameter of half the rim and dovetailed or doweled and glued into the rim. At the best, considering the grain of the wood, it is not a reliable connection. In the larger sizes of pulleys there are four sets of spokes, while in the smaller sizes there are only two, those spanning the diameter of the two separate halves of the pulleys which are held onto the shaft by bolts passed between the laminations. When in operation, the centrifugal force tends to force the rims away from the spokes. When used in dry places, the pulley shrinks and the bolts come loose, and if not tightened at frequent intervals the pulleys are likely to go to pieces, while in a moist atmosphere the rims and spokes swell and cause the pulley to warp out of shape. I have seen a pulley carrying a 24-in. belt with one edge of one section extending an inch beyond the edge of the adjacent section.

The pulley in question was 32 in. in diameter and 7 in. face, running 538 r.p.m. It had been in service about four months when it developed a cracking noise, and before the shaft was stopped it went to pieces. The face of the pulley was about 2½ in. from an 18-in. I-beam. And while some of the men in the plant are of the opinion that the hanger broke first, I believe the pulley broke first and probably struck or wedged against the beam, with sufficient force to break the hanger. At the same time the belt came off and about one-third of the pulley went through a window and landed in a doorway across the street 150 ft. from the shaft. The other portion of the rim was scattered in small pieces about the room. The spokes remained intact on the shaft. The rim speed of this pulley was 4,507 ft. per min., which I consider excessive for a wood pulley.

While it is desirable to use high speeds on shafting to get lighter weight, smaller sizes of pulleys and less cost for a given horsepower transmitted, I believe that where high speeds are necessary pressed-steel pulleys should be used instead of wood or cast iron, particularly when the diameter of the pulleys exceeds 20 in. and the speed is above 300 r.p.m. Wood pulleys, also split pressed-steel pulleys, are more commonly used on account of the ease with which they can be put on the shaft, while with solid iron pulleys the entire shaft and hangers must be taken down to slip the pulley over the end of the shaft. When it is desired to run shaft speeds up to 500 r.p.m. or more, the rim strength of the pulleys must be considered and a suitable factor of safety used.

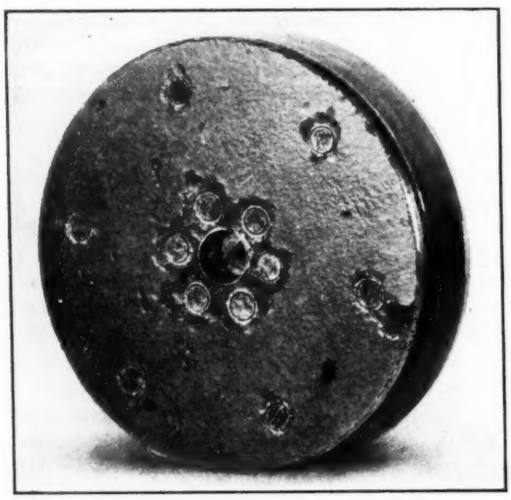
It is probable that in the near future we may see manufacturing plants running with shaft speeds of 1,000 r.p.m. or more, and if the millwrights and master mechanics supervising the erection of such machinery do not figure the safe speed of the pulleys before they are put in operation, serious accident may result. Then again, they may figure what in their judgment is a safe speed, and after a few years the engineer is asked to increase the speed of the engine several revolutions per minute, which might increase the speed of the shafts and pulleys 100 r.p.m. or more with disastrous results.

As a means of lessening the danger from pulleys being operated at too high speed, I would suggest that millwrights and master mechanics be licensed. This would be a guarantee of their ability to determine the safe speed of the various types of pulleys and thereby safeguard life and property. Some discussion on this subject may be of timely interest to engineers.

Cambridge, Mass. R. A. CULTRA.

Replacing a Broken Piston Under Difficulties

To replace a broken piston is not always considered a great undertaking provided there is enough time and material to do the work, but to do this on a large tandem-compound air compressor driven by tandem-compound steam cylinders, size 18 in. x 36 in. x 32 in. x



Model of temporary piston made by riveting plates over faced-off hub

20 in. x 36 in., when all that is carried in stock for repairs is an old set of worn piston rings appears to be a big job for the small shop of an iron ore mine.

The head of one of the capscrews that held the follower plate on a 32-in. air piston of our air compressor broke off when it was running at a speed of 90 r.p.m. The head of the capscrew was caught between the piston and cylinder head, and the force of the blow at this speed was great enough to break the piston up so that when the cylinder head, which did not break, was removed, all that was attached to the piston rod was the hub or central part of the piston.

This machine was supplying compressed air for rock drills, pumps and portable hoists, which required 3,000 cu.ft. of air per minute. It was running on an average of 20 hours out of every 24. Our mine at this time was employing close to six hundred men, and fully 75 per cent of them depended on this air compressor to furnish the power in order to do their work. The cylinder head was removed at 5 p.m., and as we could not obtain a new piston so that the compressor could be back on duty within a few hours, an attempt to repair it was necessary. A consultation with the foreman and workman of the mechanical department was held, each being pressed for an idea with the result that it was decided to make a temporary piston out of the remainder of the hub.

The hub of the broken piston was removed from the piston rod, placed on a mandrel and $\frac{1}{2}$ in. faced off from each end. Two circular steel plates, $32\frac{1}{2}$ in. in diameter and $\frac{1}{2}$-in. thick were obtained. These two plates were strapped on the table of a drill press and a 3-in. hole drilled centrally.

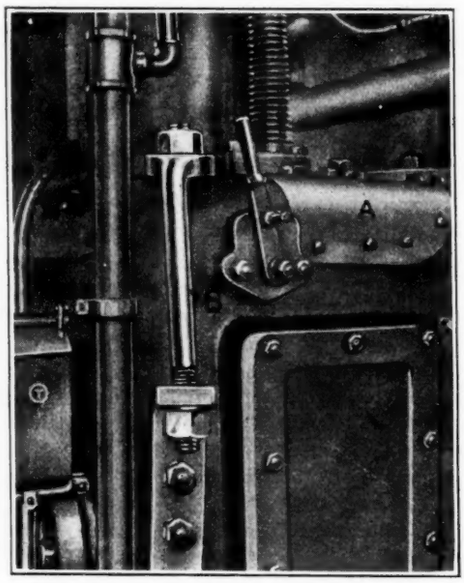
The plates were then removed and the piston hub placed between them, lined up with the holes in the plates and again bolted down on the drill-press table. Six $\frac{13}{16}$-in. holes were drilled through both plates and piston hub. Eight $\frac{13}{16}$-in. holes were drilled on a 24-in. diameter circle and the holes were then countersunk on one side. The hub was then set between the plates and the six internal rivets put in which held the plates and hub together. Eight pieces of tubing, 2x1 in., were cut in lengths as spacing pieces and the eight $\frac{3}{4}$-in. rivets were then driven through.

The piston body thus formed was put on a mandrel and turned off to 32 in. outside diameter. The old set of piston rings on hand were slipped on so it was then ready to be put in the cylinder, which was done at 7 a.m. The next morning the air compressor was again back on duty and ran with this piston for three weeks until a new one was received. The figure shows a model piston to a scale of one-eighth the original size.

Norway, Mich. THOMAS PASCOE.

A Crankcase Repair

Upon taking charge of a certain power plant in which the equipment included a gas engine, I found that the crankcase of this particular engine had been cracked from water getting into the cylinder. The crack had been welded and reinforced with plate clamps as at *A*,



Clamp used to reinforce cracked crankcase

but the job was not a success. The weld gave way and the plate clamps could not be made tight. After a little study of the job I made two heavy clamps, one of which is shown at *B*, which could be drawn up tight. With one of these clamps on each side of the crankcase the engine has now been running for several years without further trouble. L. M. JOHNSON.

Sewickley, Pa.

Comments from Readers

Gasoline Gage Glass Packing

Referring to the inquiry of S. M. B. in the Questions and Answers of the July 21 issue, I would suggest that he try rings cut from a good fine-grained grade of cork for packing his gasoline gage glasses. Cork will compress and make a satisfactory tight joint. It is not affected by gasoline and will last as long as any packing can possibly be expected to last. It may be used either with or without shellac.

Cutting packing rings and small gaskets calls for a sharp cutting tool. Why not improvise a holder for old safety razor blades and use them up? They answer the purpose better than anything I have ever tried, and they cost nothing. L. A. PIERSON.

Devon, Conn.

Let Them Down Easily

The Foreword in the May 26 issue entitled, "Let Them Down Easily," certainly had a great deal of the human in it, but in addition to letting "them down easily," is it not also a business courtesy to answer bids?

A person advertises for bids on a certain piece of work (call it a job if you please) and he receives a number of bids that state what the bidder will do and in many cases what he will charge for doing it. Frequently, details are gone into both by the bidder and the "biddee," and it does seem to me that business ethics, if nothing higher, requires on the part of the advertiser to the unsuccessful applicant an acknowledgment of the receipt of the application and a statement to the effect that the advertiser thought "it to his advantage to award the work to another party." But this is an element of human nature, and it may not be business ethics to waste time on those who lost out.

It has always seemed to me that the losing contestants are deserving of more credit and praise than are accorded them, for it is obvious that the winner could not have won the contest if it had not been for the second fellow. I hope that your friendly article will bear fruit and those who advertise will show some consideration for those who respond.

Dorchester, Mass. W. K. CAMPBELL.

Large Savings Possible by Using Exhaust in Place of Live Steam

Much has been written and said about the value of exhaust steam, and this value is being recognized more and more, but constant repetition is necessary, therefore I was glad to read the editorial in the issue of July 21 on this subject.

There are many quickly apparent applications for using exhaust steam; there are also many, not so apparent, which a little thought and study will develop. There are thousands of instances where solutions are made to boil through the use of high-pressure steam introduced directly into the solution, where low-pressure steam could be used equally well. In many plants this has been disputed until a positive demonstration was made, resulting finally in a large reduction in the total amount of steam taken from the boilers.

There are industries in which a large quantity of warm water is necessary, and this can be provided through generating units operating under vacuums of 26½ to 27 in. with very slight reduction in economy of the units and a tremendous gain in recovery of heat. In woolen and worsted mills nearly all the power can be a byproduct of the heat required to warm water for dyeing, washing and other purposes around the mill.

Hot-water heating systems present wonderful opportunities for heat recovery. The water in the system can be circulated through a surface condenser into which a power unit exhausts and the vacuum in the condenser adjusted to the temperatures required in the heating system, which may be from 140 deg. minimum to 200 deg. maximum.

For a large part of the heating season in this latitude 18 in. or 20 in. vacuum can be carried with a satisfactory water rate for the generating unit. It is probable that in many cases it would pay to change over a direct steam-heating system to a hot-water system owing to the economical regulation of temperatures. There are industries where a high humidity or even an atmosphere of steam at atmospheric pressure is required.

It would be difficult to say how many millions of dollars might be saved annually in New England alone through the substitution of low-pressure for high-pressure steam, to say nothing of the more obvious instances where low-pressure steam is obtained through the use of a reducing-pressure valve instead of from the exhaust of a prime mover. WARREN B. LEWES.

Providence, R. I.

Shall He Take a Chance?

The letter by Gordon G. Brown in the May 26 issue, entitled, "Shall He Take a Chance?" discusses a condition that is a near-tragedy. The position of the self-trained man is becoming anything but encouraging. That he is doomed, except in rare instances, to minor positions seems certain. And there seems to be no remedy immediately at hand. Apparently, he must wait until the rhythm, to which all things are subject, returns him to a more favorable position.

Now what is the difference between the college-trained and the self-trained man? Is there an inherent difference making the college man superior? Is he favored with a better grasp of technology, or is he favorably circumstanced by conditions that have a social origin? I am inclined to believe the latter.

The larger part of the knowledge of engineering is

contained in the literature of the subject—in books and periodicals. The larger part of the knowledge of engineering is imparted by means of these publications, which are available to everybody. Then why is the one who has received his education in the classrooms of a university better qualified than he who delved at midnight in a hall bedroom and who gets up at six in order to be at the shop in time for the day's work? It all seems to reduce to a matter of native ability. I grant the advantages of class spirit, the help of fellow-students and professors (although this help may be a positive detriment), but speak now of essentials. The shop practice afforded by universities is good, but falls short of the practice given by shops engaged on commercial work. So, if the equipment possessed by the college man, and not possessed by the self-trained man, is social in its nature, wherein does the college man excel as an engineer?

The greatest advantages of a university training, it seems to me, are those afforded by the prestige of the institution and the friendships formed during school years; that is, social factors. How many men owe their success in life to the influence brought to bear in their behalf by school friends? The self-trained man does not have the backing of a great institution, and he has no "school friends." That self-trained men get anywhere is greatly to their credit.

There has been, and is, some feeling between the so-called practical man and the college man, which extends to the man in the engineering department or drafting-room, who may not be a college man. Should an error find its way from the engineering department to the shop, you may be assured that it will be thoroughly aired. An error of the shop is usually "scrapped" and the work resumed on new material and with a minimum of discussion. The man in the shop delights to "get the fellow with the slide-rule." All of which is but a manifestation of the "inferiority-complex." We love to "get something on" the other fellow. It enhances our standing—in our own eyes, at least.

On the other hand, we have the recent graduate from a school of engineering. He has studied engineering four years and has learned it. Hasn't he a degree that declares him an engineer? And do not the universities inculcate the belief that engineers can be made in four years? Or at least are not loud in checking the error? Yes, sir! This lad goes out into the world a full-fledged engineer! Shortly he meets with such practical things as the best thickness of gaskets; that there is a best way to tighten up bolts in a pipe-flange; why pipes are taper-threaded; that laboratory experiments cannot always be carried out successfully on a commercial scale; that a pulley can be removed from a shaft comparatively easily by combining twisting with axial driving; that a wooden frame is a poor support for transmission machinery because of shrinkage of wood; that belts run toward the "low" side of straight pulleys and toward the "high" side of conical pulleys; that "jumpy" chain drives can sometimes be made to run smoothly by a slight adjustment of sprocket centers; and thousands of "kinks" and obscure facts that can be learned only by experiment. The timid and sensitive ones, under the influence of their practical associates, begin to feel that the university is a delusion and a snare; those with confidence and self-assertion adapt themselves and accept the work as post-graduate, and necessary instruction. Others soon enter the sales field, and some with means establish themselves in the business of engineering and hire the necessary brains and knowledge.

The man to be pitied is the one engaged in engineering on a salary. He is usually a poor salesman and hence lacks self-assertiveness. Considering the ability, preparation and responsibility demanded in engineering, it is the poorest occupation I know anything about. And yet the schools of engineering and universities turn into the world a steady stream of men who are doomed to work for years at lower wages than are paid mechanics. And these universities, maintained at public expense, are asking additional appropriations in order to enlarge the facilities for quality-production. All institutions, whatever their origin or prompting cause, tend to self-perpetuation and increase.

The engineering employer approves of quantity production of engineers. It gives him a large assortment from which to select when shopping for help. It also helps to keep salaries down. It is hard on the engineer, however. What to do about it has been discussed at great length. The very nature of engineering is fatal to the just compensation of its devotees. It makes a powerful appeal to the constructive instinct and thereby imposes a handicap that reacts against the material welfare of those engaged in it.

The condition discussed by Mr. Brown—the relegation of the self-trained man to a subordinate position—will probably continue until the public at large learns that knowledge, however gained, is knowledge still. But because the colleges control to a large extent the machinery of propaganda, this will take some time. I have heard sneering references by university men to correspondence instruction. Yet many universities provide "extension courses" which are nothing else than correspondence courses. One might, in this instance, recall the adage about imitation being flattery. A great philosopher once expressed "an abiding faith in the self-regulation of internal social activities." Self-regulation of the condition under discussion, however, will take more time than anyone can wait, so it seems that the victims must make the best of things as they are, keeping hope within bounds and thereby disappointment at a minimum. C. O. SANDSTROM.

Los Angeles, Calif.

Mr. Brown's letter interests me because at his age I was in practically the same position and he reflects some of my views at that time.

He will see differently in time, if he keeps an open mind: meanwhile, he has no need to get discouraged.

It is true that the college graduate has the prestige of his school behind him, and often that which is more important—social influence—in securing employment or advancement; but it must be remembered that he has to "make good" afterward, and that in general he does so is due to his college training in clear thinking.

Mr. Brown must have been reasonably successful in educating himself or he would not be a draftsman. He has a start in a good trade, and how proficient he becomes depends on how well he learns to think in the future. A man can study and read indefinitely, yet fail to develop initiative which is only a name for ability to think for himself clearly enough to have the courage of his convictions and carry the task to which he is assigned to a finish on his own responsibility.

The "go getter," the man with initiative, the man who will take responsibility, will get his chance whether

he is a college graduate or self-educated. The latter will be as successful as the former, if he has trained his mind equally well.

There are plenty of ways for a man to secure the equivalent of a college education; in fact, it is possible to secure the entire curriculum of a certain Western University through correspondence courses, but it means more effort than the average man is willing to make.

Assuming that a man has educated himself, he has then to learn the most important part of all, and that is, how to sell his services. He is in much the same position as a firm trying to introduce a new breakfast food, in competition with a well-known and advertised brand. It can be done, but it requires time and persistent publicity, and the latter is exactly what is needed to place a self-educated man on a par with a college graduate. If he secures a position, he must be prepared to hold it, and more than education is needed in most cases, namely, personality and judgment.

If Mr. Brown will consider for a moment that a graduate of a technical college has put in some 8,000 hours of study and attendance at lectures during his four years' course, and that this represents approximately ten years of self-instruction, assuming fifteen hours per week for a year of fifty weeks, he will see that he has a hard task before him but need not become discouraged until he is ten years older; by then he may not be an engineer, but he should be earning a reasonably good salary.

As to there being no chances of advancement for any but the college-trained man in the concern for which he is working, I should judge that to be a rare case. If that is so, and he is satisfied he possesses the necessary training for an advanced position, he should not forget that there are other places; but, remembering my own experience, he should be prepared for some rude shocks.

A frank talk with some older and more experienced man, preferably technically trained (the writer has always found such men only too glad to extend a helping hand) would be advisable before taking any drastic steps.

C. M. DINGIN.

Providence, R. I.

Listing of Parts Used in the Power Plant

I note in the May 10 issue a letter from L. A. Cowles on "Listing of Parts Used in the Power Plant." A system such as he outlines is of the greatest value to an engineer in charge of the operation of a plant, and even more so to the engineer in charge of the maintenance and repairs. I have used a system along the lines he suggests, but perhaps a little more intricate as was necessary to suit conditions where there was a large assortment of machinery.

The following is a brief description of a system that can be elaborated or simplified according to the class of machinery in question.

We use a filing card about 5x8 in. for each piece of equipment. Each machine is first given a number. This number is attached to the machine and is a means of identifying it if moved to another position. On the card is then written the name of the piece, followed by the make, serial number and any other identifying marks. In the case of pumps we included the capacity, speed head, size of suction and discharge, how driven, and date installed. In the case of motors we add the speed, rating, phases, cycles, type, maker's name and number, etc., for the different machines, so that we have a correct inventory with full information on everything in the plant.

Next to be determined are the spare parts that must be carried in stock; these are also put on the card. A duplicate of the card is then given to the storekeeper or purchasing agent, in order that he may have this information for his books, and know what spares should be kept in stock.

In order that the chief engineer may have an accurate record of what repairs are being done, it is next necessary to enter on the card the repairs that have been made, also when the spares as shown on the card have been used.

That this may be done systematically, we use cards of different colors. One, the breakdown card, is filled

No. of Machine 317

Description -: Centrifugal pump, direct-connected, double-suction
Make and Number -: United Iron Works No. 124-36
Capacity -: 1000 Gal. Per Min. Head 150 ft. 4-in. suction
5-in. discharge

Remarks-: All parts cast iron, shaft monel metal

Duty-: Condensate to hotwell. Installed 2-4-23
Transferred from raw brine pump house

Spares to be carried-: One impeller, set of bushings, and thrust bearing

Repairs-: New impeller 2-8-24
Thrust bearing overhauled 3-10-24

Reproduction of card used for recording details of equipment

in by the operator or engineer stating that the machine was down, and that the master mechanic, or whoever was directly responsible for the repairs, had been notified. It also shows the time that the breakdown occurred. This card is filed in a rack in the foreman's office. In the case of a prolonged repair it is replaced by another, with a report from the repair foreman, explaining the nature of the repair, together with an estimate of the time necessary for the work. On completion of the work a clearance card is made out and signed by the operating foreman. These cards are then turned in to the engineer's office and filed for record purposes, but not until the machinery card has been completed from these work cards.

By this means, it is possible to have a complete record of the performance of any piece of equipment and to analyze the cost of maintenance and repairs to it. Also with regard to the keeping of the spares, which is strictly a storekeeping proposition, I find that with co-ordination from that department, it is an easy matter to be sure that they are in stock, or that steps are being taken to procure them.

The system as outlined here may sound a bit cumbersome, but once it is got going, with the helpful assistance of all concerned, it is a great assistance in the keeping of a plant in an efficient and economical manner, free from the many delays caused by the spare equipment not being on hand. The illustration shows a card such as we use for recording the detail of a pump.

MAURICE C. COCKSHOTT.

Los Angeles, Calif.

Questions and Answers

Conducted by

Franklin Van Winkle

Locating Air Leaks in Boiler Setting

What is a good method of determining the locations of air leaks in a brick boiler setting? *M. E. L.*

Air leaks can be located by suddenly closing the stack damper when firing so heavily as to produce smoke. Smoke then will issue from all cracks or crevices in the setting that are responsible for any considerable air leakage. Infiltration of air around door frames, blowoff pipes or through cracks in the setting is also revealed by slowly passing the flame of a lighted match or candle over such places at a time when there is a hot fire on the grates, with ashpit and firedoors closed and the stack damper open.

Expansion cracks are likely to recur in the same places or new cracks will be developed in other parts of the setting if the crevices are filled with solid masonry. Openings should be filled with asbestos wool, firmly packed but not driven up hard with a calking tool, using mortar, clay or asbestos cement only for pointing.

Suction Lift Less Than Height Corresponding to Atmospheric Pressure

What height of water column is balanced by the pressure of the atmosphere, and why cannot a pump raise water the same height by suction lift? *C. J. K.*

Standard atmospheric pressure at sea level is that which is exerted by a column of mercury at the temperature of 32 deg. F. and 760 millimeters, or 29.921 in. high, which is equal to 14.696 lb. per sq.in. Ordinarily, this is taken as 14.7, or approximately 15 lb. per sq.in. The atmospheric pressure at a place depends on the elevation and varies with weather conditions. The actual pressure is shown by a barometer. The standard atmospheric pressure of 14.7 lb. per sq.in. is equal to the pressure exerted by a standing column of distilled water 33.947 ft. high at the temperature of 62 deg. F. Hence with a perfect vacuum at the upper surface of the water the height of water column at the temperature of 62 deg. F. that would be balanced by the standard atmospheric pressure would be about 34 ft., and the greater the elevation above sea level or less the atmospheric pressure from any cause, the less the height of water column balanced by the actual pressure of the atmosphere.

However, there could not be a perfect vacuum above the surface of the water or in a pump cylinder, because at all temperatures above freezing the water would vaporize. For instance, at the temperature of 62 deg. F. the water would burst into vapor when the pressure became reduced to that exerted by a column of mercury 0.56 in. high, which is equal to about ¼ lb. per sq.in., and this pressure would be further increased by liberation of air out of the water. The pressure thus developed on the top of the column of water reduces the height of water column that can be balanced by the pressure of the atmosphere. When a pump is in operation and the suction water is in motion, part of the atmospheric pressure is employed in overcoming frictional resistances to the passage of the water through the foot valve, suction pipe, elbows, pump suction chamber, suction valves and passages to the pump cylinder. On account of the resistances and losses of atmospheric pressure the greatest suction lift that is practical at sea level, with the water at ordinary atmospheric temperature and with the frictional losses due to a moderate velocity of the suction water, is about 22 ft. This may be less from liberation of an unusual quantity of air out of the water; or from leakage of the pump piston or of air drawn into the suction connections through bad joints, perforations of the suction pipe, or insufficient submergence of the end of the suction pipe, the lift may be reduced to zero.

Proximate Analysis of Coal

What is the difference between proximate and ultimate analysis of coal? *P. L. S.*

The proximate analysis assumes the coal to contain fixed carbon, volatile hydrocarbon, or volatile matter, or simply volatile, moisture and ash. The percentage of moisture is determined by maintaining a small quantity of finely ground coal at a temperature of about 200 deg. F. until there is no appreciable reduction of weight. The material lost in this manner is assumed to be moisture. Volatile matter is determined by heating a sample from which the moisture has been driven, or a fresh sample, for which purpose the coal is held at a red heat to white heat, with exclusion of air, until there is no further loss of weight. Fixed carbon is found by combustion of a sample from which moisture and volatiles have been driven off; and ash is the designation for the incombustible material left after determining the fixed carbon. The sum of the volatile, hydrocarbon and fixed carbon is called the combustible. When sulphur is to be reported, it must be determined by a separate analysis. The ultimate analysis is a thorough chemical analysis for determining the percentages of carbon, hydrogen, oxygen, nitrogen and sulphur and the percentage of ash in dry coal.

Locating Faults in Field Coils

An electrical engineer at my request tested six shunt-field coils with a megger on a 150-kw. rotary converter. He pronounced most of them good and a few slightly off. I insisted that the field coils were burned out. We brought the coils to our shop and rewound five. The sixth one was new from the factory. All of the five coils were burned out. The one that showed the

best insulation between the winding and ground, was burned worse than any of the others. The engineer also tested for drop across the field terminals and found the coils all right. The wires were kept apart by the charred insulation between the layers, and while the fields were cold, the drop tested correctly. When the six field coils had 275 volts applied to them, they got hot under load and gave a lot of trouble. What is the best way to test burned-out field coils under this condition? *W. H. K.*

A megger cannot be used to test the condition of the insulation between turns of the field coils. When testing the insulation of the coils to ground, the readings of the megger may not mean much as to the general condition of the coils' insulation. For example, one turn of a coil might be dead grounded and the coil otherwise all right. On the other hand, the coil may have absorbed moisture and would show a low resistance to ground. In neither case is the coil burned out. It is entirely possible for the coils to be badly roasted and show a comparatively high resistance to ground. Where a coil is roasted out, the cause of the trouble is not in this coil but in the other coils, as a short-circuit in one coil of a group will tend to reduce the temperature of the faulty coil and increase the heating of the other coils in the group.

Connecting the field coils across the line and taking the voltage drop across each coil with a voltmeter is the best way to detect if the coils are short-circuited. This, however, does not indicate that they are burned out, since there may exist a short-circuit between one lead and a turn in the coil, in such a way as to cut part of the coil out of circuit. The only thing necessary to do in this case is to reinsulate the spot where the insulation has failed.

The fact that all the field coils got hot at the same time, indicated that they were not short-circuited, for if they had been, the one good coil would have burned out while the others probably would have remained cool. When a short-circuit exists in a field coil, it is not this one that burns out but the good coils. This does not mean, however, that the coils were not in bad condition when they were taken out of the machine, since as stated the insulation could be badly roasted on the coils without causing a short-circuit.

It may be that the machine has been operating at a higher voltage than the field coils are designed for. The heating increases as the square of the current, therefore the temperature goes up quite rapidly as the voltage increases.

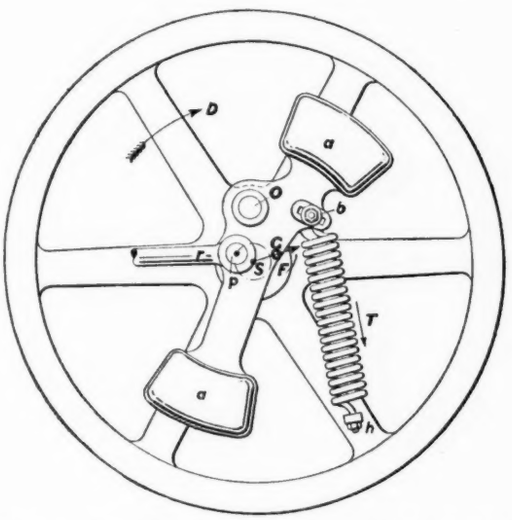
Action of Inertia Governor

How is quicker regulation of speed with change of load obtained with an inertia governor than with a simple shaft governor? *R. L.*

In a shaft governor without inertia effect a change of the relative position of the eccentric or valve-rod pin, with respect to the crank of the engine, is accomplished solely by a change of centrifugal force of the governor weight or weights, due to variation of the speed. In the inertia governor inertia of the weight as well as centrifugal effect is employed for changing the governor position for a change of speed due to a change of load, and the governor action is thereby hastened.

The operation may be understood from the illustration, which shows the general arrangement of an inertia governor to be carried by a governor wheel mounted on the overhung end of the shaft. Weights *a* and *a* are fastened to a bar or "weight-arm" that is pivoted on the governor wheel at *O*, and a pull spring is attached to the weight-arm at *b* and to the wheel at *h*. The direction of rotation of the wheel is indicated by the arrow *D*, the center of the shaft is at *S* and the center of gravity of the weight-arm with weights *aa* is at *G*. The valve rod is connected to the weight-arm by a pin at *p*. If the governor is placed on a wheel that is mounted between bearings of the shaft, then the weight-arm would be made to clear the shaft and, in place of a pin *p*, there would be an eccentric sheave mounted on the weight-arm with a slot or opening through it large enough to permit the eccentric sheave to be moved across the shaft when the weight-arm is swung on the pivot *O*.

With the governor pulley keyed on the engine shaft, and rotation in direction of the arrow *D*, a reduction of the load is accompanied by increase of the speed and



Type of inertia shaft governor for overhung wheel

greater centrifugal force carries the center of gravity *G* radially from the center of the shaft in the direction of the arrow *F*, with increase of tension on the spring in the direction of the arrow *T*. But from inertia the weights *aa* lag behind the speed of the wheel and the weight arm turns on the pivot *O* with reference to the wheel, causing elongation of the spring with tension *T* sufficiently increased to balance the centrifugal force in much less time than if the frictional and other resistances had to be overcome by action of the spring alone.

When the engine speed is decreased by an increase of load, the action is reversed. Inertia of the weights *a* and *a* then carries them in advance of the rotation of the wheel, and the weight arm is carried around the pivot *O* in the direction of rotation in advance of the wheel, causing the pull of the spring to be relaxed from becoming shortened during a small fraction of revolution of the wheel, until the tension *T* again balances the centrifugal force with a position of the valve-rod pin (or center of the eccentric) appropriate for movement of the valve rod *r* to obtain later cutoff.

[Correspondents sending us inquiries, should sign their communications with full names and post office addresses. This is necessary to guarantee the good faith of the communications.—Editor.]

New and Improved Equipment

Allis Adjustable Delivery Motor Drive

Industrial requirements for adjustable speed may be divided broadly into those applications requiring continuously constant speeds and those which require only that a constant average speed be maintained. To meet this second classification, the Louis Allis Company, Milwaukee, Wis., has developed an alternating-current motor drive having equal advantage with the direct-current motor in giving an infinite number of speeds. This drive consists of three elements, the L-A multi-speed alternating-current motor, a revolving drum for establishing the average speed, and contactors for switching the motor to the proper speed.

In the motor two or more independent windings are placed in the same core to give the proper number of poles and the consequent desired speed. The motors are usually wound for speeds corresponding to 6 and 12 poles on 60-cycle circuits and 4 and 8 poles on 25-cycle circuits. They are built for two and three-phases and for almost any frequency. Once the speeds have been established, the motor has the characteristics of a squirrel-cage motor possessing in particular its simplicity and inherent speed regulation in that the speed does not vary with the load, desirable in any adjustable-speed drive.

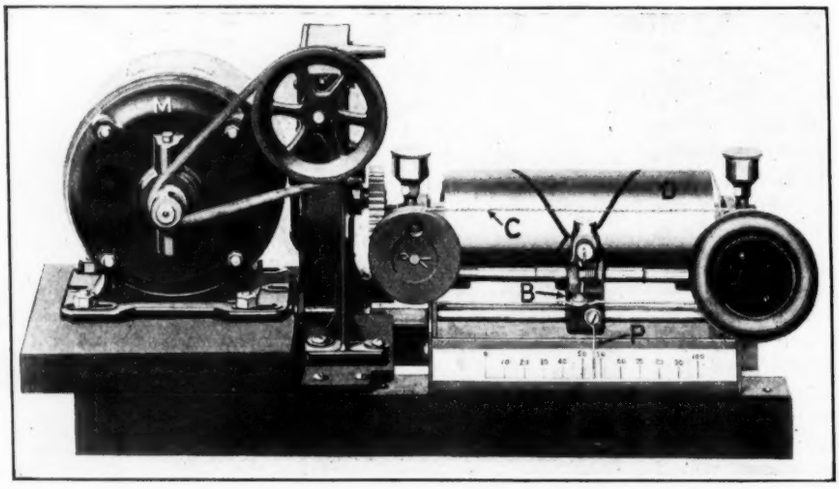


Fig. 1—Three-section drum and its driving mechanism which forms one of the elements of the new Allis adjustable delivery motor drive

Fig. 1 shows the control drum, which consists of a copper cylinder *D*, divided into sections insulated by air gaps. The drum is rotated by a small polyphase motor *M*, at a speed approximating one revolution per minute. Bearing upon the drum are stationary brushes, not shown in the figure, one for each of the windings of the multi-speed motor being controlled, and in addition one adjustable brush *B*, mounted on a slide which permits movement along the total length of the drum. The movable brush is positioned as desired on the cylinder by a steel cable *C* passing over two pulleys, the shaft of one pulley extending to a handle located on the outside of the cabinet in which the control drum mechanism is inclosed. A pointer *P* attached to the movable brush indicates the brush position and the average speed on a scale, which may be calibrated to read in tons per hour for stokers, feet per minute for conveyors, etc. The drum with its mechanism is the same regardless of the size of the multi-speed motor being controlled and may be mounted at any convenient place.

Each segment of the revolving drum is in effect one terminal for a winding of the multi-speed motor. The adjustable brush in contact with the drum closes the circuit through the contactors for that winding connected to the particular segment in contact. Segments of the drum are so designed that with the drum revolving at 1 r.p.m., the interval in any given minute during which the adjustable brush completes the circuit for each of the motor speed windings is directly proportional to the distance at which the adjustable brush is placed from the end segment.

Fig. 2 will assist in explaining the principles of operation. For simplicity take a multi-speed motor of 600 and 1,200 r.p.m., a two-speed control drum, and only five different speeds. It is assumed that the split section of the drum covers 6 in. of the length of the drum and that points *A*, *B*, *C*, *D* and *E* indicate different positions of the adjustable brush equi-distant from each other. When the adjustable brush is at point *A*, the motor runs at the minimum speed of 600 r.p.m. at all times. With the adjustable brush moved to *B*, 1½ in. from *A*, the motor will run for ¾ min. on the 600-r.p.m. winding and for ¼ min. on the 1,200-r.p.m. winding, giving an average speed of 750 r.p.m. With the adjustable brush moved to *C*, 1½ in. from *B*, or 3 in. from *A*, the motor will run for ½ min. on the 600-r.p.m. winding and ½ min. on the 1,200-r.p.m. winding, with an average speed of 900 r.p.m. At *D*, the average speed will be 1,050 r.p.m. and at *E*, with the adjustable brush in contact only with the right-hand segment of the drum, the motor will run at 1,200 r.p.m. at all times. It is evident that between 600 and 1,200 r.p.m. there is an infinite number of average speeds possible and that the speed increase is directly proportional to the distance the adjustable brush is moved.

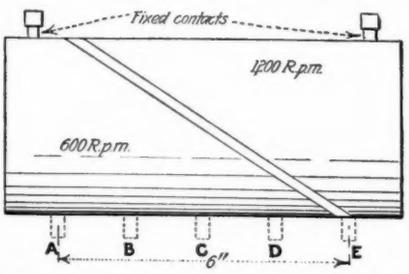


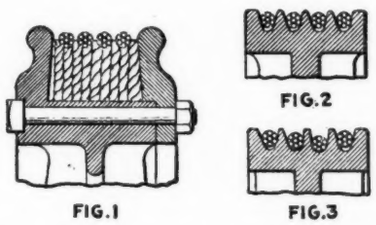
Fig. 2—Diagram illustrating principle of operation

While only two-speed adjustment has been described, the operation is fundamentally the same using three different speeds on a three-speed motor, the control, in this instance, consisting of a three-section drum such as is shown in Fig. 1. Such a drum also can be used with a zero speed adjustment for operation with a two-speed motor, making it possible to get any average speed from zero to the maximum speed of the motor. By replacing the hand-wheel of the adjustable brush with a small sheave, pulley or sprocket, the average speed may be controlled automatically from a suitable source. The new drive is in operation on stokers and conveying systems of various kinds, and it is being applied to other fields.

Truing the Grooves in Traction Elevator Sheaves

On single-wrap traction elevator machines—that is, the type in which the cables run directly from the car over the traction sheave to the counterweights—there are two types of sheave used, cast iron with some form of a V-groove for the cables, and the fiber-packed type. In the latter the face of the sheave is built up of short

lengths of hemp rope or other kind of fiber placed on end and held by bolts between two heavy iron flanges, as indicated in Fig. 1. The fiber is held under heavy pressure, which makes it a solid mass. After the sheave has been assembled, it is put into a machine and the grooves, which are semicircular in form, are rolled in. With this arrangement an iron or steel cable runs in grooves in a hemp surface and gives sufficient traction between the cables



Figs. 1 to 3—Sections of single-wrap traction-elevator sheaves

Fig. 1—Shows construction of hemp-fiber packed sheave. Fig. 2—Section of V-grooved sheave with all grooves the same size. Fig. 3—Grooves worn to unequal diameters on a V-grooved sheave.

and sheave, using single-wrap roping without having to resort to the pinching action of the V-groove used in the metal sheave, Fig. 2.

With the fiber-packed sheave as with other types trouble is experienced with the grooves wearing so that the ropes run on unequal diameters, as indicated in Fig. 3. Where the grooves have unequal diameters, the ropes on the smaller-diameter grooves must slip a certain amount to maintain the same

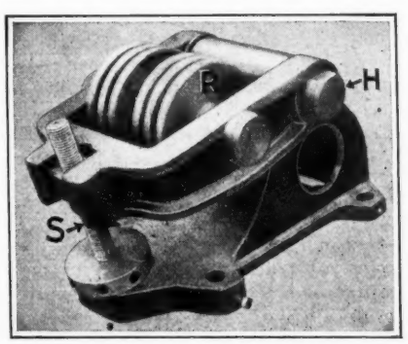


Fig. 4—Tool for correcting unequal wear in fiber-packed sheave

speed as those running on the larger-diameter grooves. This slipping tends to increase the wear and make the conditions worse. On the metal sheave not only are the grooves worn, but the cables will wear to different diameters.

When the grooves on a metal sheave become worn, it is the practice to remove the sheave, take it to a machine shop and turn the grooves to the proper shape and equal diameter in a lathe. In some cases the lathe tool is mounted on the machine and the grooves trued up in place, using the motor to drive the sheave. Either method requires shutting down the machine and removing the cable from the sheave. Turning the grooves to the same size and diameter does not completely remove the trouble. Owing to the cables being of unequal diameters, the smaller ones will go down farther in the V-grooves and there will still be a differential wear between the cables and grooves.

Recently, the Neenan Elevator Corp., 90 West St., New York City, manufacturer of the fiber-packed sheave, has developed a device, Fig. 4, for bringing the grooves in these sheaves to the same diameter. This tool has integral rollers *R*, the number of rollers corresponding to the grooves in the sheave. These rollers are supported in a yoke

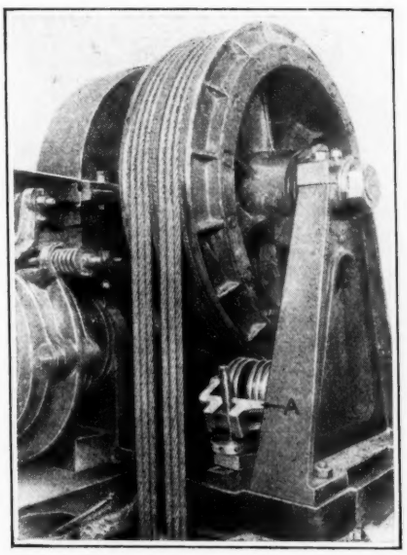


Fig. 5—Tool shown in place at A to correct groove wear in traction sheave

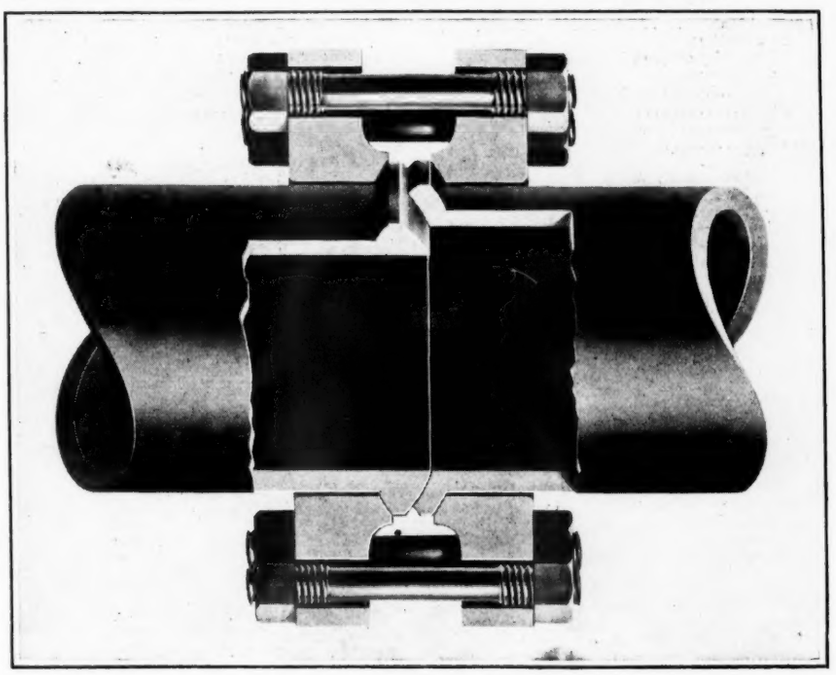
that is hinged at *H* and can be raised and lowered by the adjustment screw *S*. To equalize the diameter of the grooves, the tool is placed under the sheave, as indicated at *A* in Fig. 5, and properly lined up, after which the rollers are pressed up into the grooves by the adjusting screw, while the elevator is in operation. The large-diameter grooves will come in contact with the rollers first and will be pressed to the same diameter as the smaller-diameter grooves, thus removing the groove differential from the sheave.

Another form of the tool is to mount it on a slide rest like a lathe tool so that the rollers may be moved in against the grooves in the sheave, the rollers being made in the form of a power-operated cutting hobb.

Midwest Joint for High Pressures and Temperatures

The Midwest Joint, made by the Midwest Piping & Supply Co., of St. Louis, Mo., was described on page 748 of the May 12 issue. Three applications as follows were illustrated by half-tone cuts: Pipe-to-pipe joint; joint between pipe and valve or fitting; joint between valves and fittings. Because of space limitations these cuts were made rather small and for this reason failed to bring out certain features as sharply as could be desired.

The accompanying cut shows the pipe-to-pipe joint reproduced on a scale large enough to bring out the details clearly. The Midwest Joint is particularly designed for high pressures and temperatures and eliminates gaskets without reverting to field welding. A joint between two lengths of pipe is made by contact of the specially machined convex and concave spherical surfaces. The contact surfaces between the flanges and the back faces of the caps are also spherical. The spherical feature is designed to assure a tight joint even where the pipes are several degrees out of line. For further details, including the application of this principle to the other types of joints just mentioned, the reader is referred to the original article.



Pipe-to-pipe joint

Suggested Rules for the Care of Power Boilers*

Proposed as an addition to the A. S. M. E. Boiler Construction Code

IT IS the request of the Committee that these proposed rules be fully and freely discussed so that it may be possible for any one to suggest changes before the rules are brought to final form and presented to the Council for approval. Discussions should be mailed to C. W. Obert, Secretary of the Boiler Code Committee, 29 West 39th St., New York, N. Y., in order that they may be considered by the Boiler Code Committee.

Appendix

FEED-WATER ANALYSIS, TREATMENT AND CONTROL

Work in Laboratory

CA-1. The recommended procedure for the chemical treatment of boiler feedwater is to have a water chemist (*a*) make a complete technical analysis of the feedwater; (*b*) determine the amount and kind of chemicals required; (*c*) supply reagents and apparatus for making a few simple tests on the raw and treated boiler water and condensate to check the results in the field; (*d*) determine the total solids in solution in the boiler, the alkalinity, the chlorides, the sulphates, the ratio of chlorides to total solids, the ratio of chlorides to sulphates, and the ratio of total alkalinity in terms of sodium carbonate to the sulphates in terms of sodium sulphate.

ANALYSIS FORM A—TECHNICAL WATER ANALYSIS FOR INDUSTRIAL PURPOSES

Determinations	Grains per Gallon
Suspended Matter	
Dissolved Matter:	
Total solids by evaporation	
Organic matter	
Total alkalinity as $CaCO_3$	
Free CO_2	
Free H_2SO_4	
Free H_2S	
Silica, SiO_2	
Oxides of Fe and Al; Fe_2O_3 and Al_2O_3	
Calcium hardness as $CaCO_3$	
Magnesium hardness as $CaCO_3$	
Aluminum hardness as $CaCO_3$	
Ferrous or ferric hardness as $CaCO_3$	
Manganous hardness as $CaCO_3$	
Total hardness as $CaCO_3$	
CaO	
MgO	
Na_2O	
FeO or Fe_2O_3	
Al_2O_3	
MnO	
CO_2 (fixed)	
SO_3	
Cl_2	
N_2O_5	
H_2O in hydroxides	
Color, Pt. Co. Std.	(p.p.m.)
Turbidity, Silica, Std.	(p.p.m.)
Oxygen consumed	c.c. per liter
Dissolved oxygen	c.c. per liter
pH (Hydrogen-ion concentration)	

*The rules were presented at a public hearing at the A.S.M.E. Spring Meeting in Milwaukee. On account of the length of the rules *Power* is printing them in short installments, of which this is the ninth and last.

ANALYSIS FORM B—PROBABLE COMBINATIONS—WATER FROM NATURAL SOURCES

(1)

1-CaO–1-CO_2 { Fixed / Half-bound }
2-MgO–2-SO_3
3-Na_2O–3-Cl_2
4-N_2O_5

(2)

1-MgO–1-CO_2 { Fixed / Half-bound }
2-CaO–2-SO_3
3-Na_2O–3-Cl_2
4-N_2O_5
(May not give any $CaCO_3$)

(3)

1-CaO–1-SO_3 { Fixed
2-MgO–2-CO_2 { Half-bound
3-Na_2O–3-Cl_2
4-N_2O_5
(May not give any $CaCO_3$)

ANALYSIS FORM C—PROBABLE COMBINATIONS—SOFTENED WATER

Softened Water	Softened Water or Concentrated Softened Water	
1-CaO–1-CO_2	MgO	H_2O in hydroxides
2-MgO–2-SO_3	Na_2O	
3-Na_2O–3-Cl_2	*CaO	
4-N_2O_5	Na_2O	CO_2
		SO_3
	Na_2O	Cl_2
		N_2O_5

Total alkalinity (as $CaCO_3$) exceeding the equivalent of CaO and MgO as $CaCO_3$ and no hydroxide present. Total alkalinity (as $CaCO_3$) exceeding the equivalent of CaO and MgO with hydroxide present.

* If CaO exceeds the CO_2 then combine the excess with H_2O in hydroxides. Analysis then to show $CaCO_3$, $Ca(OH)_2$, and $Mg(OH)_2$ and NaOH, but neither $MgCO_3$ nor Na_2CO_3.

ANALYSIS FORM D—TECHNICAL WATER ANALYSIS—IONIC

Determinations	Parts per Million
Suspended Matter	
Dissolved Matter	
Total solids by evaporation	
Organic matter	
Total alkalinity as $CaCO_3$	
Free CO_2	
Free H_2SO_4	
Free H_2S	
Silica, SiO_2	
Oxides of Fe and Al; Fe_2O_3 and Al_2O_3	
Calcium hardness as $CaCO_3$	
Magnesium hardness as $CaCO_3$	
Aluminum hardness as $CaCO_3$	
Ferrous or Ferric hardness as $CaCO_3$	
Manganous hardness as $CaCO_3$	
Total hardness as $CaCO_3$	
Ca	
Mg	
Na	
Fe	
Al	
Mn	
HCO_3	
CO_3	
SO_4	
Cl	
NO_3	
OH	
Color, Pt. Co. Std.	
Turbidity, Silica Std.	
Oxygen consumed	c.c. per liter
Dissolved Oxygen	c.c. per liter
pH (Hydrogen-ion concentration)	

ANALYSIS FORM E—PROBABLE COMBINATIONS—WATER FROM NATURAL SOURCES

(1)

1-Ca–1-CO_3 and HCO_3
2-Mg–2-SO_4
3-Na–3-Cl
4-NO_3

(2)

1-Mg–1-CO_3 and HCO_3
2-Ca–2-SO_4
3-Na–3-Cl
4-NO_3
(May not give any $CaCO_3$)

(3)

1-Ca–1-SO_4
2-Mg–2-CO_3 and HCO_3
3-Na–3-Cl
4-NO_3
(May not give any $CaCO_3$)

ANALYSIS FORM F—PROBABLE COMBINATIONS—SOFTENED WATER

Softened Water	Softened Water or Concentrated Softened Water	
1-Ca–1-CO_3	Mg	OH
2-Mg–2-SO_4	Na	
3-Na–3-Cl	*Ca	
4-NO_3	Na	CO_3
	Na	SO_4
		Cl
	Na	NO_3

Total alkalinity (as $CaCO_3$) exceeding the equivalent of CA and Mg as $CaCO_3$ and no hydroxide present. Total alkalinity (as $CaCO_3$) exceeding the equivalent of Ca and Mg with hydroxide present.

* If Ca exceeds CO_3 then combine the excess with OH. Analysis then to show $CaCO_3$, Ca $(OH)_2$, Mg $(OH)_2$ and NaOH but neither $MgCO_3$ nor Na_2CO_3.

Quick Laboratory Test for Determining the Soda Treatment for a Raw Water

CA-2. To 100 cc. of a representative sample of raw water add 10 cc. of a soda solution containing 85 per cent by weight of carbonate of soda and 15 per cent by weight of caustic soda.

Boil together six minutes in a water bath or preferably in a receptacle under 15 lb. pressure; filter through a 6-in. filter paper and titrate while still hot against an N/25 normal sulphuric acid solution, using preferably 5 drops of a 5-grain-per-liter alcoholic solution Dimethylaminoazobenzene (butter yellow). Continue this titration until the yellow color of the indicator starts to turn red. Next, similarly treat and titrate 100 cc. of distilled water.

Carefully note the cubic centimeters (cc.) of acid used in each test.

No Soda Treatment is indicated where the cc. of acid used in testing the raw water exceeds those used in testing with the distilled water-and-soda solution.

A soda treatment is indicated where the cc. of acid used in the test with the distilled water exceeds those used in the test of the raw water.

The difference between the cc. in this last relation times 1.9 gives the pounds of soda ash for 10,000 gallons of the water when treated under ideal conditions.

To meet the waste of soda through blowdowns or other causes, it is necessary to treat in excess.

The actual rate of soda required to remove all calcium and magnesium salts from the water within the boiler according to the ammonium oxalate test (Test D in Par. CA-26), divided by the rate of soda as determined by the raw-water test, gives a factor. This varies and should be determined at each plant and be used in conjunction with the raw-water test when necessary.

Chemical Control in the Field

CA-3. To avoid boiler corrosion through the presence of magnesium or calcium chlorides, nitrates or sulphates, or combinations of sodium chloride and

magnesium sulphate, it is recommended that the concentrations of free sodas within all steaming boilers be kept in excess of 15 grains per gallon in terms of sodium carbonate.

CA-4. Where mineral acidity exists in a raw water the minimum alkalinity of such a water shall be made to exceed one grain per gallon and be preferably under the direction of an expert feedwater chemist and engineer. Such waters should be tested frequently when intermittent contaminations of this character are known to exist.

CA-5. Where feedwaters contain free soda as bicarbonate, carbonate or caustic, it is recommended to establish a relation between the total alkalinity in the boiler in terms of sodium carbonate and the sodium sulphate as follows:

For working pressures of 150 lb. and under, alkalinity not to exceed the sodium sulphate; for working pressures over 150 lb. and under 250 lb., alkalinity not to exceed ½ the sodium sulphate; for working pressures of 250 lb. and higher, alkalinity not to exceed ⅓ the sodium sulphate.

NOTE—The theory has been advanced that in the absence of sulphates in the boiler water, sodium hydroxide formed in the boiler saline may, by some corrosive action, accelerate the formation of cracks in overstressed material. This theory is based on the following facts: Cracks have been found in leaking riveted seams of a small number of steam boilers fed with natural artesian well waters high in sodium carbonate and very low in sulphates, and in certain geographical districts in some boilers fed with condensed steam from caustic evaporators, and in some boilers fed with water distilled from sea water to which considerable amounts of sodium carbonate were added. Others contend that such cracks may be entirely explained by either faulty material or excessive internal stresses in the plates resulting from the manufacture or the operation of the boiler and by incorrect thermal or mechanical treatment of the plates, or by several of these causes combined. Nevertheless, the adherents of this theory suggest the maintenance of this sodium sulphate-carbonate ratio stated in Par. CA-5 in the hope that it will be beneficial and will help to decrease the number of cracks in riveted seams. Whether the control of the sodium sulphate-carbonate ratio will produce the desired results is a matter which experience over a considerable period alone can tell, and CA-5 is therefore suggested, pending the collection of further experience.

CA-6. When the carbonate hardness in a water exceeds the permanent hardness by more than 3 grains per gallon, or when sodium bicarbonate is present in excess of 3 grains per gallon, then treatment should be made to remove free carbon dioxide and to reduce the carbonates before using either soda or softening for removal of permanent hardness.

CA-7. The directly applied treatment of a raw feedwater with sodas for the removal of calcium and magnesium sulphates, chlorides, nitrates, and neutralization of mineral acids should be regulated by tests of the blowdown water to keep total alkaline concentrations within a limit to insure the removal of all hardness, and also by tests of the same water for detecting the presence of any calcium salts that remain as the result of inadequate soda treatment.

CA-8. For continuous softening system the samples of treated water for testing purposes should be made up from samples drawn at regular intervals over the day, or, should be a bleeder sample regulated to flow uniformly into a large glass bottle during the same period. The bottles for holding and gathering the treated water samples should be kept closed as much as possible.

For the batch or intermittent softening systems, an equal sample of water should be taken from each tank after it is treated. Equal precautions against exposure to the air should be observed in gathering these samples.

CA-9. Where samples are drawn at intervals, they should be tested promptly. The same regulation applies to bleeder samples, but in the latter case the large bottle is emptied after each test for refilling. These provisions should be made to avoid contamination of the samples with carbon dioxide.

CA-10. All samples of condensate, treated water, and raw water for testing purposes shall be collected at regular intervals over a 24-hour period or be a bleeder sample taken from a location that is in constant use. The sample of blowdown water for this purpose shall be taken from the boiler operating the greatest number of steaming hours. The containers for collecting these samples should be kept clean and contents be exposed as little as possible to the air.

CHECK TESTS IN THE FIELD WITH RAW WATER

Lime Required for Reduction of Carbonate Hardness

CA-11. Determine the alkalinity by Test A (see Par. CA-22) then multiply grains per gallon of alkalinity by 0.09, which gives approximately the pounds of lime (90 per cent available calcium oxide) required per 1,000 gallons of water.

Titrating a 100-cc. sample, then the number of cc. of acid used times 0.05 equals pounds of lime (90 per cent available calcium oxide) per 1,000 gallons. For hydrated lime add 33⅓ per cent to weights found by these determinations.

Soda Required for Reduction of Permanent Hardness

CA-12. To 58.3 cc. of the filtered water add the same amount of N/50 sulphuric acid as was required for the alkalinity determination with methyl orange. Pour this neutralized water into a test bottle and add standard soap solution (1 cc. = 1 milligram $CaCO_3$) slowly, ½ cc. at a time, shaking after every addition, and finally adding five drops at a time between shakings until the lather persists for 3 minutes. From the number of cc. of soap solution used, subtract 0.5. The remainder equals the total hardness of the water expressed as grains per gallon of calcium carbonate, or with a 100-cc. sample after subtracting 0.9, the remainder gives parts per 100,000 which, multiplied by 10, equals p.p.m.

CA-13. If the hardness is more than 10 grains, dilute the sample with an equal volume of distilled water, take 58.3 cc. of this diluted sample and repeat the soap test. Subtract 0.5 cc. and double the remainder to get grains per gallon. From the hardness subtract the alkalinity, add 1.5 and then multiply by 0.16. The result gives the pounds of soda ash required per 1,000 gallons of water; but if the alkalinity exceeds the hardness, then the difference multiplied by 1.06 gives the grains per gallon of sodium carbonate present in the untreated water and no soda will be required.

CA-14. If with a 100-cc. sample the hardness is more than 170 p.p.m., dilute the sample with an equal volume of distilled water, take 100 cc. of this diluted sample and repeat the soap test. Subtract 0.9 cc. and multiply the remainder by 20 to get the total hardness in parts per million (p.p.m.) of calcium carbonate. From this hardness, subtract the p.p.m. of alkalinity, add 25 and then multiply by 0.0094. The result gives the pounds of soda ash required per 1,000 gallons of water; but if the alkalinity exceeds the hardness, then the difference multipled by 1.06 gives the p.p.m. of sodium carbonate present in the untreated water and no soda will be required.

CA-15. Chlorides shall be determined by Test C (see Par. CA-24).

WITH TREATED WATER

CA-16. (*a*) Hydroxides and carbonates shall be determined by Test B (see Par. CA-23).

(*b*) Calcium in solution shall be determined by Test B (see Par. CA-26).

WITH BLOWDOWN WATER

CA-17. (*a*) Hydroxides and carbonates shall be determined by Test B (see Par. CA-23).

(*b*) Chlorides shall be determined by Test CC (see Par. CA-25).

(*c*) Sulphate relation to chlorides shall be determined by laboratory methods only (see a water chemist).

(*d*) Calcium in solution shall be determined by Test D (see Par. CA-26).

(*e*) Foaming tendency of water shall be determined by Test E (see Par. CA-27).

CA-18. Where softened water is used for boiler feed or where soda treatment is used directly in the feed, the alkalinity in the boiler consists mainly of two constituents: sodium hydroxide (caustic soda) and sodium carbonate (soda ash). Determine the relation between these two by a titration with two indicators, preferably phenolphthalein (Pht) and methyl orange (MO) on a fair sample of the blowdown water. This should be done regularly after the required minimum alkalinity is determined and maintained in each boiler.

CA-19. Suppose an alkalinity of 30 grains per gallon has been determined

with MO. If this were all due to sodium carbonate, then a titration with MO would give 30 (510 p.p.m.) and one with Pht 15 (255 p.p.m.) or half as much. If this alkalinity were all due to sodium hydroxide, the Pht and MO would each give 30 (510 p.p.m.) or the same. In a blowdown water the Pht is usually more than half the MO, or the MO less than double the Pht:

Example:

Pht 25	MO 30	H 20	C 10
(425 p.p.m.)	(510 p.p.m.)	(340 p.p.m.)	(170 p.p.m.)

H means hydroxide and is found by doubling the Pht and then subtracting the MO. C means carbonate and is found by subtracting H from MO. In this example, the alkalinity 30 (510 p.p.m.) is practically composed of sodium hydroxide 20 (340 p.p.m.) and sodium carbonate 10 (170 p.p.m.)

With Condensate and Trap Discharges

CA-20. (*a*) Alkalinity shall be determined by Test A (see Par. CA-22).

(*b*) Chlorides shall be determined by Test C (see Par. CA-24).

With Condensate from Surface Condenser

CA-21. Determine chlorides by Test C (see Par. CA-24).

Tests

Test A for Alkalinity

CA-22. For this test the temperature of the samples should not exceed 100 deg. F.

Titrate 58.3 cc. of the clear filtered water in a beaker with N/50 sulphuric acid using 1 drop of MO solution as indicator. Add the acid slowly with constant stirring until the yellow color deepens to an orange tinge. The number of cc. of acid used equals the alkalinity in grains per gallon. Titrating a 100-cc. sample, then the number of cc. of acid used = parts per 100,000 which × 10 = p.p.m.

Samples of water treated at temperatures less than 180 deg. F. should first be heated close to boiling point in a water bath, then cooled and filtered.

Test B for Hydroxides and Carbonates

CA-23. The temperature of the sample should not exceed 100 deg. F.

First, fill the burette to the zero mark with N/50 sulphuric acid; then carefully clean the measuring flask, rinse twice with the filtered sample to be tested and fill to the 58.3-cc. mark. Pour into a clean beaker that has been rinsed twice with the filtered sample and add one drop of Pht, which will turn the water pink. Now, without delay, drop into the beaker just enough of the acid to change the water to colorless, stirring constantly and adding the acid drop by drop. Record this reading of the number of cc. of acid drawn and mark it Pht. Make this test quickly and do not expose to smoke or breath.

After the Pht reading is recorded, add one drop of MO to the same water in the beaker, which will turn the water yellow. Continue dropping the acid from the burette into the beaker with constant stirring, until the color deepens to an orange tinge; counting from zero record the total number of cc. of acid drawn and mark it MO.

(To assist the eye in detecting the exact point at which the color of the Methyl Orange changes from yellow to orange, use a second beaker with 58.3 cc. sample of water to be tested with one drop of Methyl Orange added, and stir until color is uniform. Place this beaker beside the titration beaker and note the point at which one drop of the acid will cause the color in the titration beaker to deepen, as it changes from yellow to orange.)

Multiply the Pht reading by 2 and from the product subtract the MO reading. Mark the difference H. Subtract H from MO reading and mark the difference C. Then, in normal cases when calcium and magnesium are both low:

H × 0.8 = grains per gallon sodium hydroxide.

C × 1.06 = grains per gallon sodium carbonate, approximately. With a 100-cc. sample:

H × 8.0 = p.p.m. sodium hydroxide.

C × 10.6 = p.p.m. sodium carbonate, approximately.

Test C for Chlorides in the Feedwater or Condensates

CA-24. The temperature of the sample should not exceed 100 deg. F.

To. 58.3 cc. of the clear filtered water in a beaker add 10 drops of 2 per cent solution of potassium chromate and titrate with a standard solution of silver nitrate (1 cc. = 1 milligram chlorine) until a faint orange tinge appears which is best seen in yellow light (yellow curtain or amber glasses over a white surface). The number of cc. of silver nitrate used equals grains per gallon chlorine. On 100 cc. sample, cc. used × 10 = p.p.m. chlorine.

Test CC for Chlorides in the Boiler Water

CA-25. The temperature of the sample should not exceed 100 deg. F.

To 58.3 cc. of the clear filtered water in a beaker add one drop of phenolphthalein. If the water turns pink add just enough dilute sulphuric acid (N/50 or N/10) to change the pink to colorless. Then add 10 drops of a 2 per cent solution of potassium chromate and titrate as in the preceding case with standard silver nitrate solution of convenient strength (say, 1 cc. equals 10 milligrams chlorine; consult the chemist) and find the grains per gallon chlorine; this divided by the grains of chlorine found in the feedwater gives the number of concentrations now present in the boiler water.

Using a silver nitrate solution of which 1 cc. = 10 milligrams chlorine, then operating on a 58.3-cc. sample, cc. used × 10 = grains per gallon chlorine; operating on a 100-cc. sample, cc. used × 100 = p.p.m. chlorine.

When the chlorine in the sample exceeds 30 grains (510 p.p.m.) take one measure (58.3 cc.) and dilute it with three measures of distilled water. Test one measure of the diluted sample as before, multiply the result by 4 and then by the proper factor to get grains per gallon.

Or dilute a 100-cc. sample with 300 cc. distilled water, test 100 cc. of the diluted sample, and multiply by 4, and then by the proper factor to get p.p.m.

Test D for Calcium in Solution—Qualitative Test for Calcium

CA-26. Filter the sample until perfectly clear; test it with a strip of red litmus paper; if it does not turn the paper blue, add ammonia, drop by drop, with shaking, until the water turns the paper blue. Fill a clean 6-in. test tube half-full with this clear alkaline water and add 5 drops of ½ normal ammonium oxalate solution, shake and let stand one minute. Ignore any faint cloud that develops on standing. A prompt fine white precipitate shows high calcium requiring soda ash for its removal. It may also result from using too much caustic lime or caustic soda. Consult the chemist.

Test E for Foaming Tendency of Water—Approximate Tests for Foaming

CA-27. Fill a clean pint bottle half-full with partly cooled filtered blow-off water, cork, shake violently, and lay on its side. If a distinct foam persists, check the feedwater for oil, grease, or sewage contamination, and also consult a qualified steam engineer or chemical engineer.

Machine Tool Exhibition September 8-11

The Machine Tool Exhibition which is held annually at the Mason Laboratory, Sheffield Scientific School of Yale University, is this year scheduled for Sept. 8-11. The general committee in charge of the arrangements has been working since last November and has practically all the details completed. The personnel of this committee is as follows: H. R. Westcott, chairman; E. Hartford, assistant chairman; S. W. Dudley, secretary; W. W. Gaylord, treasurer; J. D. Marsh, superintendent; K. F. Lees, publicity; E. Oberg, technical sessions; William Buxbaum, planning; E. W. O'Brien, relations with other organizations; C. Oppe, information, tickets, registration. The demand for exhibition space has been so great on the part of firms from the Middle West as well as from the eastern part of the country, that it has been necessary to open additional space on two floors of the Mason Laboratory and to arrange to hold all technical sessions in the Dunham Laboratory of electrical engineering.

St. Croix River Power Plants.—Surveys have been completed and plans are under way for the two new water-power plants that the Wisconsin-Minnesota Light & Power Co. is to build on the St. Croix River, which forms part of the boundary between the two states. One of these plants will be built at Kettle River Rapids, about 40 miles above St. Croix Falls. The head here will be about 80 ft. and the installed capacity about 40,000 hp. This construction will involve an expenditure of more than $5,000,000. The second plant, which will be nearer St. Croix Falls, will have an ultimate developed head of about 105 ft. and will involve an expenditure of approximately $3,000,000. The main undeveloped powers of the Wisconsin-Minnesota Light & Power Co. are three on the Red Cedar River and seven on the Chippewa River.

Bituminous Coal Output Increases

Coal production, which has lagged somewhat during recent months, is now shown in the weekly-production studies of the Bureau of Mines to be increasing.

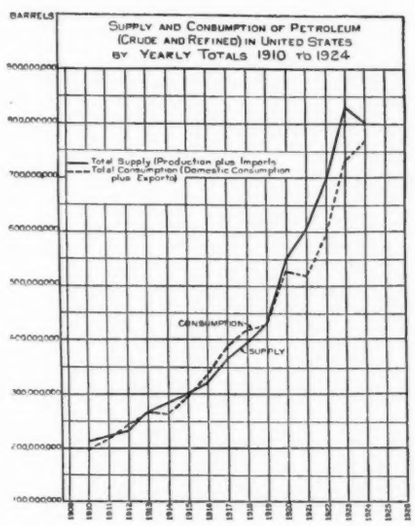
For the week ended July 25, the bureau reported the total output of bituminous in the United States was 9,255,000 tons, against 8,966,000 the preceding week and 7,785,000 during the corresponding week of last year.

Standard Oil Co. Turbine Blower Wrecked

On July 29 at the Whiting plant of the Standard Oil Co. of Indiana, one man was fatally injured and several others received minor injuries, as the result of an explosion of a 20-in. turbine blower used to improve the draft of a return-tubular hand-fired boiler. The machine was being overhauled, and before the fan had been put on and the governor connection made, steam was turned on to try out the rotor of the turbine. Evidently, the unloaded rotor acquired such speed as to burst from the action of centrifugal force.

Oil Report Issued by Mining and Metallurgical Society

The Mining and Metallurgical Society of America, No. 2 Rector St., New York City, has just issued its new special report on "Supply, Consumption and Stocks of Petroleum in the United States" from 1910 to date as Bulletin No. 176. The figures on which the report was based were obtained from the official statements of the United States Geological Survey, Bureau of Mines and Bureau of Foreign and Domestic Commerce. Charts of trends, production, consumption and stocks are included.


BARRELS
SUPPLY AND CONSUMPTION OF PETROLEUM (CRUDE AND REFINED) IN UNITED STATES BY YEARLY TOTALS 1910 TO 1924
Total Supply (Production plus Imports)
Total Consumption (Domestic Consumption plus Exports)
CONSUMPTION
SUPPLY

Willys-Overland Combines Stokers and Wood Waste

Wood waste from its body building plant is to be used as fuel by the Willys-Overland Co., of Toledo, in conjunction with coal in the plant which will supply power to its large new drop-forging plant. The coal will be burned on six Taylor underfeed stokers under the same number of 640-hp. boilers. Chutes and a conveyor system will introduce the wood above the stoker fuel bed, as is now being done at the plant of the Fisher Body Corp., Detroit, where similar stokers are used. The Fisher Body Corp. plant is two years old, and its experience has shown that this method of burning wood waste is entirely practicable.

It is planned to operate the Willys-Overland boilers at an average rating of over 200 per cent. When necessary, they can be forced to nearly 300 per cent to take care of peak loads. Stokers of the type used have a very flat efficiency curve, even at ratings as high as 400 per cent, and respond quickly to sudden demands for steam, which makes them especially adapted to plants of this kind, where the load is likely to change rapidly without warning. Experience has shown that the introduction of wood above the fuel bed makes little difference in the performance of the stokers.

Governor Pinchot Outlines His Idea of the Duties of a Public Service Commission

Says That Commission Should Be Militant Advocate and Vigilant Protector of Rights of the People

GOVERNOR PINCHOT on July 30 summarily discharged James S. Benn from the Public Service Commission of the Commonwealth of Pennsylvania. The Governor called Mr. Benn out of the hearing of the Philadelphia Rapid Transit Co.'s 7½-cent fare case and ordered him to report immediately to the executive office in Harrisburg. When Mr. Benn arrived at the executive office, the Governor asked him to resign, and when Mr. Benn refused he was told that he was discharged. The Governor then appointed Dr. Clyde L. King, Secretary of the Commonwealth to the Public Service Commission in Mr. Benn's place.

The Governor gave Mr. Benn a formal letter of dismissal which read in part:

"The purpose, and the only purpose of a Public Service Commission is to protect the public interest. It cannot rightly have another object. Unless it acts as the militant advocate and vigilant protector of the rights of the people, it is useless or worse.

"No Public Service Commission that expects to serve the public can afford merely to wait for cases to be submitted to it. It must act upon its own initiative. The vital duty of a Public Service Commission is, upon its own motion, to protect the public. To do so it must seek out, take up and deal with cases in which the public interest is involved, but which without its action would never come before it.

"One most serious fault of the average Public Service Commission is that it is satisfied to decide cases on the information before it, when it is obvious that the public side has not been adequately presented. It can do its duty only by making certain that the facts are as fully presented on the public side as on the corporate side.

"When the facts are equally presented on both sides the commission should be the judge, but simply to act as a judge on the evidence, knowing full well that the public side has not been brought out is just another way of deciding against the public. In a private case the contestants in the long run will be equal. In utility cases they seldom are.

"An effective Public Service Commission should also establish and keep up to date standards and policies that will enable it to dispose of disputed cases justly, effectively, cheaply and quickly as they arise. Many a commission has allowed itself to become so overwhelmed and befogged by individual cases that it has no time for policies and standards, no time for considering the general public common interest, no time for leadership.

"The reason why any Public Service Commission worth its salt must take this position, is that unless it does so the rights of the people will not be protected. The average citizen cannot compete in litigation with a public corporation. In most cases he cannot do for himself at all what a live Public Service Commission can easily do for him. He may know that he has been wronged, but he has little notion of how to secure redress. Nine times out of ten he has so little confidence in the Public Service Commission of his state, even if he knows about it, that he does not appeal to it, and nine times out of ten he is right.

"I have both the right and the duty to discuss the policies and standards of the Public Service Commission, but I have never at any time indicated to

any member of the commission what his decision should be in any individual case and I never will. I have insisted and I do insist, that the business for which the Commission exists is the active protection of the public rights. Unless that duty is courageously, vigorously and effectively performed, the commission must fail.

"Let there be no misundertstanding, public-utility corporations exist by grace of the people for the service of the people. That is the reason, and the only reason, why the people authorize them to exist. As the Supreme Court of the United States has said, 'They are endowed by the state with some of its sovereign powers, such as the right of eminent domain, and so endowed by reason of the public service they render.'

"That being true, it is equally true that the welfare of the public requires that corporations which do adequately serve the public shall receive a fair return, no less and no more, upon the money invested in them. Unless public-utility corporations properly handled and giving proper service to the public are permitted to earn reasonable returns upon the money actually and prudently invested, new money will not be invested, necessary extensions of lines and service will not be made, and the public interest will suffer.

"It is, therefore, as much the duty of a Public Service Commission militantly active in the public interest to safeguard the legitimate interest of the corporations as it is to safeguard the legitimate interests of the public.

"The cases in the history of public utilities in the United States in which the interests of the companies have been overlooked are, however, rare, while cases in which the interests of the public have been forgotten are innumerable.

"In the reconstruction of the Public Service Commission, which has followed the refusal of the Legislature to confirm my appointees, my purpose has been to bring together a body of men with the point of view here set forth. A Public Service Commission which is not ready and willing, of its own motion, to take up the cause of the public and act as its fighting defender, merely cumbers the earth."

Cameron Falls Plant Ready for Service

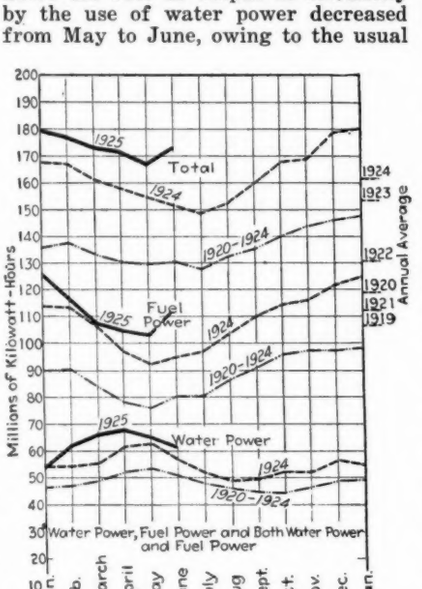
The fifth unit of electrical development at Cameron Falls will be ready for operation the second week in August. The sixth and last units of the devlopment will be completed some time in October. The station when complete will comprise six complete sets of generators with an output of 12,000 volts, which is stepped up to 110,000 on the transmission line.

Ericsson's Memory Honored by Swedish Engineers

The memory of John Ericsson, inventor of the "Monitor" of Civil War fame, was honored on July 31 at the annual dinner of the John Ericsson Society at the Engineers Club, 32 West Fortieth St., New York City. Among the speakers were Lieut. Commander John H. Barnard, U. S. N.; C. C. Hulth, of the G. E. Co.; J. Skogmark, one of the inventors of smokeless powder, and Charles K. Johansen, editor of the *Swedish North Star*. A radiogram of congratulation was read from the Mayor of Filipstad, Sweden, Ericsson's birthplace. Frank Mossberg, past president of the society, was toastmaster.

Production of Electricity by Public Utility Plants

The average daily production of electricity by public-utility power plants in June was 173,500,000 kw.-hr. —about 3½ per cent larger than the average daily output for May. The curves below indicate that there was a decided increase in the average total daily output of electricity for June. Since the rate of output of electricity by the use of water power decreased from May to June, owing to the usual



Note: *Average daily production is obtained by dividing the total for the month by the number of days in the month*

Central Stations, Electric Railway Plants, and output of other Plants Generating Electricity for Public use

Electricity Output Curve Goes Up

seasonal decline in the flow of streams, the increase in the average daily rate of the production of electricity by the use of fuels was most pronounced, according to the Geological Survey.

The average daily production of electricity for each month in this year by public-utility power plants and the proportion produced by water power were as follows: January, 179,700,000 kw.-hr.—31 per cent; February, 177,900,000 kw.-hr—35 per cent; March, 173,000,000 kw.-hr.—38 per cent; April, 171,700,000 kw.-hr.—39 per cent; May, 167,400,000—39 per cent; and June, 173,500,000 kw.-hr.—36 per cent.

G. E. Investigation Now Under Way

A report that the investigation of the General Electric Co. had been completed has been denied by Chairman Van Fleet, of the Federal Trade Commission. The inference of the report was that the Commission had had no difficulty in establishing all the facts necessary for its conclusions. Mr. Van Fleet stated that there is nothing to justify such a report. It is expected that several months of work will be necessary.

An indication of the thoroughness with which the Commission is preparing for this investigation is had in the fact that the economists assigned to the investigation have made a detailed study of the plant of the Potomac Electric Power Co., in Washington, so as to familiarize themselves with the conduct of a large central station. It has been decided to report on some of the engineering phases of the business.

The report that the investigation had been concluded came on the heels of a revival of the erroneous statement that the Commission had dropped the General Electric study on the ground that such work was precluded by the appropriation act which became effective July 1. As was explained at that time the appropriation act was interpreted as applying to a small portion of the work only. The major purposes of the Senate resolution are being carried out diligently.

The investigation has not progressed very far. Little work on it could be done prior to July 1, owing to the necessity of concentrating personnel on the investigations which had to be concluded before the end of the fiscal year. Since July 1 there has been some delay in getting the work under full headway because of the vacation season.

It was stated at the Commission that the General Electric Co. is placing no obstacles in its way and has shown every disposition to co-operate. Not only have prominent officials of the company called on Chairman Van Fleet to pledge their full co-operation, but those of the Commission's staff who have visited the general offices of the company have been furnished all the information they have sought.

Another 1200-Lb. Installation

According to press reports, confirmed by officials of the company, the Milwaukee Electric Railway and Light Co. has plans for a 1,200-lb. boiler and turbine installation. This, while similar in principle to the Weymouth unit, will, it is understood, differ in certain details, especially the boiler. We are informed that plans are not far enough advanced to warrant a tentative description at this time, but it is hoped that further details will be available shortly.

50,000-Kw. Unit for Waukegan Station

The Public Service Company of Northern Illinois has recently ordered a 50,000-kw. steam-turbine unit for the Waukegan Station. This is the third unit, the first being one of 25,000 kw., which was installed two or three years ago, and the second of 35,000 kw., installed last winter. This indicates not only rapid growth in the load of this station, but also the progress being made by the Allis-Chalmers Manufacturing Co. in the large steam-turbine field, this being the largest unit thus far undertaken by that company.

Business Notes

The Layne & Bowler Co., Memphis, Tenn., manufacturer of deep-well vertical centrifugal pumps, has just purchased equipment for a new test plant.

The Marion Machine, Foundry & Supply Co., Marion, Ind., has had to increase the size of its New York City office and announces that after August 1 it will be located at 30 Church Street.

The Cutler-Hammer Manufacturing Co., Milwaukee, Wis., has recently purchased the business and patents of Payne Dean Limited, and will continue the development and manufacture of these devices and will also market them. The Dean valve control has always been manufactured by the Cutler-Hammer Manufacturing Co., and they have also recently manufactured much of the other equipment sold by Payne Dean, Ltd., such as the auxiliary power-plant apparatus, including the Dean signal systems, switchboards, load indicators, etc. Mr. Dean and many of his associates are now connected with the Cutler-Hammer Manufacturing Co. and will actively assist in the promotion of the business.

The Fuller-Lehigh Co., Fuller, Pa., has closed negotiations with Acers-Poppenhusen Co., McCormick Bldg., Chicago, Ill., as its special sales representatives for its company in the Midwestern territory. The principal officers of the Acers-Poppenhusen Co. are Ralph Acers and P. Albert Poppenhusen, both of whom have been identified as specialists in power-plant equipment for many years past. Their sales activities for the present will be centered upon direct firing installations, including the introduction and application of the Fuller-Bonnot Unit Mill and the Fuller Impact Unit Pulverizer, in connection with the utilization of pulverized fuel for boilers and furnaces.

Trade Catalogs

Aftercoolers—Pennsylvania Pump & Compressor Co., Easton, Pa. Bulletin No. 122 covers Type H-C horizontal and Type V-C vertical aftercoolers. It is illustrated and contains tables of sizes, capacities and weights.

Motors—Century Electric Co., St. Louis, Mo. Bulletin No. 38 covers the squirrel-cage induction polyphase motors, ¼ to 75 hp., Type "SC", manufactured by this company. The construction and operation of the motors are described and illustrated fully.

Power Plant Equipment—The Swartwout Co., Cleveland, Ohio. The new catalog issued by this company covers steam traps, hydromatic bucket, low-pressure float type, return, lifting and vacuum type, sediment trap and strainer; steam and oil separators of cast-iron, cast-steel and boiler-plate types, cast-iron exhaust heads, air separators, horizontal and vertical, water-level control valves, all-service open feed-water heaters and junior heaters. It is amply illustrated with photos, drawings and tables.

Coming Conventions

American Electric Railway Association. James W. Walsh, 8 West 40th St., New York City. Convention and exhibits at Young's Million Dollar Pier, Atlantic City, N. J., Oct. 5-9.

American Electrochemical Society. Dr. Colin G. Fink, Columbia University, New York City. Convention at Chattanooga, Tenn., Sept. 24-26.

American Institute of Electrical Engineers. F. L. Hutchinson, 29 West 39th St., New York City. Pacific Coast convention, Seattle, Wash., Sept. 15-17.

American Institute of Mining and Metallurgical Engineers. F. F. Sharpless, 29 West 39th St., New York City. Autumn Meeting at Salt Lake City, Aug. 31-Sept. 3.

American Society of Civil Engineers. George T. Seabury, 29 West 39th St., New York City. Fall meeting at Montreal, Oct. 14-16.

American Society of Mechanical Engineers—Calvin W. Rice, 29 West 39th St., New York City. Annual meeting at New York City, Nov. 30-Dec. 3.

American Society of Refrigerating Engineers, William H. Ross, 154 Nassau St., New York City. Annual meeting at New York City, Nov. 30-Dec. 3.

Association of Edison Illuminating Companies. Preston S. Miller, 80th St. and East End Ave., New York City. Annual meeting at New Arlington Hotel, Hot Springs, Ark., Oct. 19-23.

Association of Iron & Steel Electrical Engineers. John F. Kelly, Empire Bldg., Pittsburgh, Pa. Annual meeting at Philadelphia, Pa., Sept. 14-19.

Chemical Industries. Tenth Exposition at Grand Central Palace, New York City. Sept. 28-Oct. 3.

Electric Power Club, S. N. Clarkson, B. F. Keith Bldg., Cleveland, Ohio. Fall meeting at Briarcliff Manor, N. Y., Oct. 19-22.

Empire State Gas & Electric Association. C. H. B. Chapin, 5618 Grand Central Terminal Bldg., New York City. Meeting at Lake Placid Club, N. Y., Oct. 1 and 2.

Illuminating Engineering Society. Norman D. MacDonald, 29 West 39th St., New York City. Convention at Detroit, Mich., Sept. 14-18.

Iron and Steel Exposition. John F. Kelly, 706 Empire Bldg., Pittsburgh, Pa., Sept. 14-19. Exposition at the Philadelphia Commercial Museum, Philadelphia, Pa., Sept. 14-19.

National Association of Practical Refrigerating Engineers, Edward H. Fox, 5707 West Lake St., Chicago, Ill. Sixteenth annual convention and educational exhibition at Statler Hotel, Detroit, Mich., Dec. 8-12.

National Association of Stationary Engineers. F. W. Raven, 417 South Dearborn St., Chicago, Ill. National convention and exhibition at St. Paul, Minn., Aug. 31-Sept. 4. Annual conventions and exhibitions of state associations are scheduled as follows: **Minnesota Association** at St. Paul, Aug. 24-28. A. Nelson, 800 22nd Ave., Minneapolis, Minn.

National Exposition of Power & Mechanical Engineering. Fred W. Payne, Manager, Grand Central Palace, New York City. Exposition at Grand Central Palace, Nov. 30-Dec. 5.

National Safety Council. G. H. Cameron, 168 North Michigan Ave., Chicago, Ill. Fourteenth Annual Safety Congress at Cleveland, Ohio, Sept. 28-Oct. 2.

New England Water Works Association, Frank J. Gifford, Dedham, Mass., sec. Convention to be held aboard "Richelieu," en route Montreal to Quebec, etc., Sept. 8-11. For details apply to George E. Marsters, Inc., 248 Washington St., Boston, Mass.

Fans, Exhaust—American Blower Co., 2539 Woodward Ave., Detroit, Mich. Bulletin No. 3506 covers the "ABC" steel plate exhaust fans Type "E". Numerous tables and illustrations enliven the publication.

Valve—"S-C" Regulator Manufacturer Co. Fostoria, Ohio. Bulletin No. 700 describes the excess pressure valve, Type "S" adaptable for electric-driven boiler-feed-pump regulation, feed-water regulation, excess-pressure regulation and two-pressure feed-water regulation, manufactured by the company.

Controllers—American Schaeffer & Budenberg Corp., Berry and South Fifth Sts., Brooklyn, N. Y. Catalog No. 2500 "Honeco Air Operated Controllers for Automatic Control of Pressure, Temperature, Condensation, Humidity, Liquid Levels, Timing of Processes, Control of Dampers, etc.," has just been issued by this company. Fourteen typical installation diagrams are reproduced in blueprint form, and other important data are contained in the 60-page catalog.

Fuel Prices

COAL

The following table shows the trend of the spot steam market in various coals, f.o.b. mines; *mine run* except Pittsburgh gas slack:

Bituminous, Net Tons	Market Quoting	July 27, 1925
Pool 1	New York	$2.35@$2.75
Smokeless	Boston	1.70
Clearfield	Boston	1.65@ 1.90
Somerset	Boston	1.75@ 2.00
Kanawha	Columbus	1.35@ 1.50
Hocking	Columbus	1.45@ 1.70
Pittsburgh	Pittsburgh	1.90@ 2.00
Pittsburgh gas slack	Pittsburgh	1.40@ 1.60
Franklin, Ill.	Chicago	2.25@ 2.50
Central, Ill.	Chicago	2.00@ 2.25
Ind. 4th Vein	Chicago	2.25@ 2.50
West Ky.	Louisville	1.10@ 1.25
S. E. Ky.	Louisville	1.35@ 1.75
Big Seam	Birmingham	1.50@ 2.00
Anthracite, Gross Tons		
Buckwheat No. 1.	New York	$2.25@$2.50
Buckwheat No. 1.	Philadelphia	2.15@ 2.75
Birdseye	New York	1.60

FUEL OIL

New York—Aug. 6, light oil, tank-car lots; 28@34 deg. Baumé, 5½c. per gal., 36@40 deg., 5¾c. per gal., f.o.b. Bayonne, N. J.

St. Louis—July 29, tank-car lots, f.o.b. St. Louis; 24@26 deg., $1.75 per bbl.; 26@28 deg., $1.80 per bbl.; 28@30 deg., $1.85 per bbl.; 30@32 deg., $1.90 per bbl.; 32@36 deg., gas oil. 5.03c. per gal.; 38@40 deg., 5.47c. per gal.

Pittsburgh—Aug. 4, f.o.b. local refinery; 30@34 deg., fuel oil, 5¾c. per gal.; 36@40 deg., fuel oil, 6c. per gal.

Dallas—Aug. 1, f.o.b. local refinery, 26@30 deg., $1.45 per bbl.

Philadelphia — July 31, 27@30 deg., $2.15@$2.21 per bbl.; 18@22 deg., $1.848@$1.908; 13@19 deg., $1.575@ $1.635 per bbl.

Boston—Aug. 3, tank-car lots, f.o.b. heavy oil, 12@14 deg., Baumé, 4¼c. per gal.; light oil, 28@32 deg. Baumé, 5½c. per gal.

Cincinnati — Aug. 4, tank-car lots, f.o.b. local refinery, 24@26 deg. Baumé, 5¼c. per gal.; 26@30 deg., 5⅝c. per gal.; 30@32 deg., 5⅝c. per gal.

New Plant Construction

Ark., Ozark—City is having preliminary plans prepared for the construction of a waterworks system including pumping equipment, tank on tower, distribution mains, etc. Estimated cost $70,000. W. L. Winters, 700 South 20th St., Fort Smith, is engineer

Ga., Macon—Bd. of Water Comrs., will soon receive bids for one 500 hp. boiler for waterworks plant.

Ill., Chicago—G. M. Cohen, 1840 Broadway, New York, is receiving bids for the construction of a 6 story office and theatre building at 111 North Clark St. Estimated cost $750,000. Rebori, Wentworth, Dewey & McCormick, 332 South Michigan Ave., are engineers.

Ill., Chicago—Greater Chicago Lake Water Co., R. J. Nash, Pres., 76 West Monroe St., is having preliminary plans prepared for improvements, to furnish water to suburban cities west of here, to consist of crib approximately 3 miles in lake off 22d St., 14 ft. tunnel 165 ft. underground carrying water to pumping station at 22d St. and Harlem Ave., pumping capacity 100,000,000 gals. increasing to 300,000,000. T. J. Dolan, 5 West Monroe St., is engineer.

Ill., Great Lakes—Bureau of Yards and Docks, Navy Dept., Washington, D. C. G. A. McKay, Acting Chief of Bureau, will receive bids until August 12th for retubing and repairing ten horizontal return tubular heating boilers at the Naval Traning Station here.

Ill., Kenilworth—Bd. of Education, New Trier Township, will soon award contract for the construction of a boiler house. F. C. Warner and W. R. McCormack, Bulkley Bldg., Cleveland, are architects.

Ill., Murphysboro—The Southern Illinois Gas Co., awarded contract for power plant building to house additional 1250 kva. unit and two 500 hp. boilers, etc. also improvements to distribution system to Stone & Webster, Inc., 147 Milk St., Boston, Mass. Estimated cost $300,000.

Ill., Panama—The Cosgrove-Meehan Coal Co., plans the construction of a power plant including a 150 x 400 ft. dam to generate electricity for the mine here. Estimated cost $125,000.

Md., Baltimore—Johns Hopkins Hospital & Johns Hopkins University, Monument and Wolfe Sts. are having plans revised for the construction of an 8 story dispensary on Monument St. Estimated cost $1,500,000. J. E. Sperry, Calvert Bldg., is architect. H. F. Doeleman, 509 North Charles St., is engineer. Former bids rejected.

Mass., Boston—Statler Hotel Co., 33rd St. and 7th Ave., will receive bids until August 17th for the construction of a hotel at Columbus Ave., St. James Ave. and Province St., here. G. B. Post & Sons, 101 Park Ave., New York, are architects.

Mass., Sommerville (Boston P. O.)—Ford Motor Co., Highland Park, Mich., will soon award contract for the construction of an assembly building, power plant, etc., here. A. Kahn Inc., 1000 Marquette Bldg., Detroit, Mich., is architect.

Miss., Gulfport—J. G. Hepsher, Meridian, plans the construction of two 100 ton ice plants at Biloxi and here.

Minn., Moorhead — City voted $50,000 bonds for improvements to municipal water and light plant.

Mo., Malden—City plans election August 18th to vote $50,000 bonds for a new boiler, engine and generator for power plant, also 2 new well triplex type pumps 350 g.p.m. capacity, 100,000 gal. tank on tower, water mains. F. L. Wilcox, 924 Chemical Bldg., St. Louis, is engineer.

Mo., St. Louis—L. E. Balson, et al, 7054 Washington Ave., is having preliminary plans prepared for the construction of a 9 or 10 story hotel at West Pine St. and Kingshighway. Estimated cost $1,000,000. Private plans.

Neb., Lincoln—Eppley Hotels Co., Fontenelle Hotel, Omaha, is having plans prepared for the construction of a new steam power plant including boilers, etc. for hotel here. Cahill & Douglas, 217 West Water St., Milwaukee, Wis., are engineers.

N. H., Bethlehem—Bethlehem Electric Co., awarded contract for the construction of a dam and hydro-electric plant including intake and forebay, head gates, etc. across the Ammonusoc River to Ambursen Construction Co., Inc., Grand Central Terminal, New York. Estimated cost $100,000.

N. Y., New York—Eastern Office, Inc., 347 Madison Ave., awarded contract for the construtcion of a 30 story office building at Lexington Ave. Depew Place, 43d to 44th Sts. to Todd, Robertson & Todd Engineering Corp., 347 Madison Ave. Estimated cost $29,000,000.

N. Y., New York—C. A. Gould, c/o Warren & Wetmore, 16 West 47th St., Archt., is having plans prepared for the construction of a 14 story office building at 5th Ave. and 54th St. Estimated cost $5,000,000. H. C. Balcom, 16 East 47th St., is engineer.

N. Y., New York—Ninto Building Corporation, c/o J. M. Felson, 250 West 57th St., Archt. and Engr., will build a 15 story apartment at 2490 Broadway, by day labor. Estimated cost $1,500,000.

N. Y., New York — One Hundred and Twenty-Four West 79th St. Corp., H. Adelstein, Pres., c/o Gronenberg & Lenuchtag, 450 4th Ave., Archts. and Engrs., is having plans prepared for the construction of a 15 story apartment on West 79th St.

N. C., Raleigh—E. E. Culbreth, Mayor, and C. C. Page, Comr. of Public Works, will receive bids until August 26th for 2 motor driven centrifugal pumping units and compensators, capacity 2,100 g.p.m. each against a discharge head of 350 ft. W. C. Olsen, Masonic Temple Bldg., is engineer.

O., Akron—Northern Ohio Traction & Light Co., A. C. Blinn, Gen. Mgr., North Main St., plans the construction of extension to power plant. Estimated .cost $100,000.

O., Canton—Stark County, plans the construction of a group of buildings including boiler house for a tuberculosis hospital on Canton Alliance Road. Estimated cost $700,000. A. L. Thayer, New Castle, Pa., is architect.

O., Cleveland — Cleveland Electric Illuminating Co., Illuminating Bldg., J. Wolf. construction engineer, awarded contract for the superstructure of an electric generating station on Avon Beach to Hunkin-Conkey Construction Co., Hunkin-Conkey Bldg. Estimated cost $10,000,000.

Okla., Barnsdall—City, having surveys made for a new waterworks system including a reservoir, filter plant, pumping equipment, etc. Estimated cost $75,000. Holway Engineering Co., Wright Bldg., Tulsa, is engineer.

Okla., Cromwell—Sinclair Oil & Gas Co., Sinclair Bldg., Tulsa, will build an 8 unit absorption type gasoline plant including nine 160 hp. and two 80 hp. direct connected Cooper gas engine compressors, Braun heat exchangers, preheaters, coolers and condensers. Work to be done by company forces. Contracts for pumps, electrical equipment, etc., awarded. Estimated cost $650,000.

Okla., Elk City—L. A. Ross, Clk., will receive bids until August 18th for the construction of a new waterworks system including a filter plant, motor driven pumps, motors, spillway, mains, etc. Estimated cost $336,000. Benham Engineering Co., Gumbel Bldg., Kansas City, Mo., is engineer.

Okla., Walters—City will build a dam across the Cache Creek, also spillway, new pump, etc. Estimated cost $16,000. Work to be done by city forces under supervision of A. M. Thompson, Engr.

Pa., Philadelphia — Blumenthal Bros., Margaret and Bermuda Sts., having revised plans prepared for the construction of a new boiler house including 1 water boiler, 500 hp. coal stoker, power piping, etc. at Margaret and James Sts. Ballinger Co., 12th and Chestnut Sts., is engineer. Former bids rejected.

Tenn., Jackson—City voted $60,000 bonds for improvements to municipal light plant.

Tex., Carrizo Springs—W. H. Shaw, plans the construction of a packing and cooling plant. Estimated cost $40,000. Private plans. Owner will purchase machinery.

Tex., Crystal City—City plans an election soon to vote $25,000 bonds for improvements to waterworks system including a new well,, pumping equipment, mains, etc.

Tex., Ennis—City voted $60,000 bonds for improvements to waterworks system including a deep well, centrifugal pump, etc. H. McCanless is engineer. G. C. Sanderson is secretary.

Tex., Floresville—City plans an election August 18th to vote $40,000 bonds for improvements to waterworks including pumping equipment, additional mains, etc.

Tex., New Braunfels—Comal Power Co., subsidiary of the San Antonio Public Service Co., 201 North St. Marys St., San Antonio, E. H. Kifer, V. Pres., has acquired a new site on the Guadalupe River adjoining Landa Park for the construction of a power plant. Estimated cost $4,000,000. Company engineers in charge.

Tex., Victoria—Middle West Utilities Co., Frost Bldg., San Antonio, J. B. Morton or E. D. Udden, representatives, at Victoria, plans the construction of a turbine and electric generating plant here, is also having preliminary plans prepared for the construction of a dam across the Guadalupe River near Cuero to be used as power for a generating plant. Estimated cost $400,000 and $150,000 respectively. Company engineers in charge.

Wis., Green Bay—Byllesby Engineering & Management Corporation, 231 South La Salle St., Chicago, Ill., plans the construction of a steam power plant here. Estimated cost $2,000,000. Company engineers in charge.

Wis., Green Bay—North American Power Co., Public Service Bldg., Milwaukee, is having preliminary plans prepared for the construction of a steam power plant on the Fox River here. Estimated cost $2,000,000. E. Luber, c/o owner, is engineer. J. Anderson, c/o owner, is engineer.

Wis., Merrill—Sisters of the Holy Cross Hospital, c/o C. Bruce, Chn., is in the market for refrigeration machinery for new hospital.

Wis., Milwaukee — Milwaukee Electric Railway & Light Co., Public Service Bldg., will receive bids about August 15th for the remodeling of a 2 story public service building on Sycamore St. Estimated cost $150,000. Judell & Bogner, 445 Milwaukee St., are architects.

Wis., Prairie du Sac—Wisconsin River Power Co., L. J. Clark, Secy., Gay Bldg., Madison, having surveys made for the construction of a hydro-electric power plant on the Wisconsin River here. Engineer not selected.

Ont., Hagersville—Town plans the construction of a waterworks and fire protection systems including pumps, mains, reservoir, etc. Estimated cost $25,000 to $50,000. E. Hinchliffe, Dunnville is engineer.

Ont., Iroquois Falls — Abitibi Power & Paper Co. plans the installation of additional electric boilers and newsprint machines to increase capacity of paper mill.

Ont., Ottawa — Millson & Burgess, 185 Sparko St., Archts., will soon receive bids for the construction of a 7 story apartment including refrigeration system on Elgin St. Estimated cost $1,000,000. Owner's name withheld.

Ont., Stratford—City plans the installation of a Diesel engine for waterworks plant. A. B. Manson, City Hall, is engineer.

Ont., Thorold—Towns of Thorold and Merriton, plan the installation of a filtration plant including pumps, reservoir, etc. Estimated cost $71,000 or $98,000. E. H. Darling, Home Bank Bldg., Hamilton, is engineer.

Ont., Toronto—St. Michaels Hospital, 30 Bond St., will receive bids until August 20th for the construction of a 7 story hospital including steam heating system and elevators on Victoria St. Estimated cost $500,000. J. P. Hynes, 73 King St., West, is architect.

N. B., Grand Falls — Electric Power Comn., St. John, awarded general contract for the construction of a hydro-electric power development including dam, power house, etc., consisting of two 25,000 hp. vertical units against 100 ft. head on the St. Johns River here, to Dominion Construction Co., Royal Bank Bldg., Toronto. $1,546,556.

South Africa, Johannesburg—The National Bank of South Africa, 44 Beaver St., New York, will receive bids until October 13th for complete boiler house equipment, coal and ash handling plant, two 12,000 k.w. turbo alternators, transformers for power station, switch gear and auxiliary plant, etc. for the electric power station at Durban, for the Electricity Supply Commission Union of South Africa, 82 Marshall St., Johannesburg.

PRICES - MATERIALS - SUPPLIES

Electrical prices on following page are prices to the power plant by jobbers in the larger buying centers east of the Mississippi. Elsewhere the prices will be modified by increased freight charges and by local conditions.

SINCE LAST MONTH

Advances again predominate in the market for power plant and electrical supplies. Prices are higher than a month ago in armored cable, flexible cord, rubber covered copper wire, tape, babbitt metal and linseed oil. There is considerable fluctuation in prices of cotton waste and wiping cloths. Cold finished steel is lower in Cleveland and Chicago.

POWER-PLANT SUPPLIES

HOSE—Quotations at New York warehouses:

	Fire Protection	50-Ft. Lengths
Underwriters' 2½-in., coupled, single jacket		65c. per ft.
Common, 2½-in., cotton-rubber lined	80c. per ft. list less	45%

Air—Best grade

¾-in., per ft.	3-ply	$0.36	4 ply	$0.44

Steam—Discounts from List

First grade	40%	Second grade	40-5%	Third grade	40-10%

RUBBER BELTING—List price 6-in., 6 ply, $1.83 per lin.ft. The following discounts from list apply to rubber transmission belting:

Best grade	50-5%	Second grade	50-10-5%

LEATHER BELTING—List price, 24c. per lin.ft. per inch of width for single ply at New York warehouses.

Grade	Discount from list
Medium	40%
Heavy	30-10%

RAWHIDE LACING—For cut, best grade, 50%, 2nd grade, 60%. For laces in sides, best, 41c. per sq.ft.; 2nd, 37c. Semi-tanned: cut, 50%; sides, 41c. per sq.ft.

PACKING—Prices per pound at New York warehouses:

Rubber and duck for low-pressure steam, ¼ in.	$0.90
Asbestos for high-pressure steam, ½ in.	1.70
Duck and rubber for piston packing	.90
Flax, regular	1.10
Flax, waterproofed	1.70
Compressed asbestos sheet	.80
Wire insertion asbestos sheet	1.30
Rubber sheet	.45
Rubber sheet, wire insertion	.70
Rubber sheet, duck insertion	.50
Rubber sheet, cloth insertion	.25
Asbestos packing, twisted or braided and graphited, for valve stems and stuffing boxes	1.30
Asbestos wick, ½- and 1-lb. balls	.50

PIPE AND BOILER COVERING—Discounts, New York warehouses, are as follows:

85% magnesia high pressure		50%
For low-pressure heating and return lines	4-ply	70%
	3-ply	72%
	2-ply	74%

PORTLAND CEMENT—New York, $2.50@$2.60 per bbl. without bags, in carload lots delivered on job. Bag charge of 40c. per bbl.

STRUCTURAL STEEL—New York delivered price, 3 to 15-in. beams and channels and 3 to 6-in. angles, tees, and plates, all $3.34 per 100 lb.

COTTON WASTE—The following prices are in cents per pound:

	New York	Cleveland	Chicago
White	15@22	19.00	18.00
Colored	10.00@15.50	18.00	17.00

WIPING CLOTHS—Prices per pound in lots of about 600 lb., as follows:

	13½ x 13½	13½ x 20½
Chicago	$0.11*	$0.11*
New York	.17	.....
Cleveland (*per thousand*)	36.00	45.00

*White, at washery.

LINSEED OIL—These prices are per gallon:

	New York	Cleveland	Chicago
Raw in barrels (5 bbl. lots)	$1.06	$1.14	$0.96@1.00

WHITE AND RED LEAD—In 100-lb. kegs, base price in cents per pound:

	Dry		In Oil	
	Current	1 Yr. Ago	Current	1 Yr. Ago
Red	15.75	14.50	17.25	16.00
White	15.75	14.50	15.75	14.50

RIVETS—The following quotations are allowed for fair-sized orders from warehouse:

Rivets, ⅛x1-in. and longer, 19c. per lb., less 50% at New York warehouses. Same discount for tinned. EXTRA per 100 lb. for 1¼ to 2-in. long, all diameters, 25c.; ¾-in. dia., 35c.; ½-in., dia., 75c.; 1-in. long and shorter, 75c.; longer than 5-in., 50c.; less than 200 lb., 50c.; countersunk heads, 45c.

Structural rivets, ¾, ⅞, 1 in. diameter by 2½ in. to 4½ in. sell as follows per 100 lb.:

New York	$5.00*	Chicago	$3.50	Pittsburgh	$2.40@2.50

Boiler rivets, same sizes:

New York	$5.20*	Chicago	$3.70	Pittsburgh	$2.75@2.90

* For immediate delivery from warehouse.

REFRACTORIES—Prices in car lots f.o.b. plant:

Chrome brick, eastern shipping points	net ton	$48@53
Chrome cement, 40@50% Cr_2O_3, in bulk	net ton	23@28
Chrome cement, 40@50% Cr_2O_3, in sacks	net ton	27@32
Magnesite brick: 9-in. straights	net ton	65@68
Magnesite brick: 9-in. arches, wedges and keys	net ton	71.50@74.80
Magnesite brick: Soaps and spits	per ton	91.00@95.20
Silica brick: Mt. Union, Pa.	per M	38@40
Clay brick, 1st quality, 9 in. shapes, Pennsylvania	per M	40@47
Clay brick, 1st quality, 9 in. shapes, Ohio	per M	43@46
Clay brick, 1st quality, 9 in. shapes, Kentucky	per M	43@45
Clay brick, 2nd quality, 9 in. shapes, Pennsylvania	per M	33@40
Clay brick, 2nd quality, 9 in. shapes, Ohio	per M	40@43
Clay brick, 2nd quality, 9 in. shapes, Kentucky	per M	40@43
Chrome ore crude, 40@50%	net ton	19.00@20.50

BABBITT METAL—Warehouse prices in cents per pound:

	New York	Cleveland	Chicago
(83% tin)	60.00	65.25	60.00
(35% tin)	28.00	20.50	28.00

COLD DRAWN STEEL—Warehouse prices are as follows:

	New York	Cleveland	Chicago
Round shafting and screw stock, per 100 lb. base	$4.15	$3.80	$3.60
Flats, squares and hexagons, per 100 lb. base	4.65	4.30	4.10

BOILER SPECIALTIES—F. o. b. New York or Jersey City, discounts on list:

	Current
Copper ferrules	70%
Boiler flanges	60-10%
Boiler stay bolts	60%
Boiler patch bolts	10%
Boiler fitting-up bolts	45%
Pressed steel boiler lugs	10%
Pressed steel boiler hangers	10%

WROUGHT PIPE—The following discounts are to jobbers for carload lots at Pittsburgh mill:

BUTT WELD

Inches	Steel Black	Steel Galv.	Inches	Iron Black	Iron Galv.
1 to 3	62	50½	1 to 1½	30	13

LAP WELD

2	55	43½	2	23	7
2½ to 6	59	47½	2½	26	11
7 and 8	56	43½	3 to 6	28	13
9 and 10	54	41½	7 to 12	26	11
11 and 12	53	40½			

BUTT WELD, EXTRA STRONG, PLAIN ENDS

1 to 1½	60	49½	1 to 1½	30	14
2 and 3	61	50½			

LAP WELD, EXTRA STRONG, PLAIN ENDS

2	53	42½	2	23	9
2½ to 4	57	46½	2½ to 4	29	15
4½ to 6	56	45½	4½ to 6	28	14
7 and 8	52	39½	7 and 8	21	7
9 and 10	45	32½	9 to 12	16	2
11 and 12	44	31½			

BOILER TUBES—Following are prices in New York warehouse of tubes manufactured according to specifications of the American Society of Mechanical Engineers:

Size	Lapweld Steel	C. C. Iron	Seamless Steel
1	.....	.....	$17 07
1¼	.....	.....	19 20
1½	.....	$38 00	17 92
1¾	.....	28 50	20 48
2	$17.33	25 00	20 24
2¼	19 84	28 25	23 00
2½	21 60	34 00	26 03
3	25.50	42 50	27 04
3¼	.....	49 50	30 67
3½	31.50	52 75	33 33
4	38.03	67 00	40 11

Tubes 2¼ in. diameter, or smaller, over 18 ft. long, 10 per cent extra.

These prices are net per 100 ft. based on stock lengths. If cut to special lengths, billing will be based on the entire stock lengths.

In addition to the above, standard cutting charges are as follows:

2 in. and smaller, 5c. per cut. 3 in., 9c. per cut
2¼ and 2½ in., 6c. per cut. 3¼ to 4 in., 10c. per cut

ELECTRICAL SUPPLIES

ARMORED CABLE—Price per 1,000 ft.—5 per cent 10 days.

B. & S. Size	Two Cond. M Ft.	Three Cond. M Ft.	Two Cond. Lead M Ft.	Three Cond. Lead M Ft
No. 14 solid	$36.00 (net)	$ 50.00 (net)	$164.00	$210.00
No. 12 solid	135.00	170.00	225.00	265.00
No. 10 solid	185.00	235.00	275.00	325.00
No. 8 stranded	285.00	375.00	520.00	500.00
No. 6 stranded	400.00	500.00	560.00	.....

From the above lists discounts are:		Lead Covered
Less than coil lots	50%	25%
Coils to 1,000 ft.	55%	30%
1,000 to 5,000 ft.	60%	35%
5,000 ft. and over	60-5%	40%

CONDUIT, Price per 1,000 ft.; **ELBOWS AND COUPLINGS**, Per 100 pieces, f.o.b. New York, with 10-day discount of 5 per cent.

Size In.	Conduit Black Per M	Conduit Galvanized Per M	Elbows Black Per C	Elbows Galvanized Per C	Couplings Black Per C	Couplings Galvanized Per C
¼	$56.50	$61.34	$7.76	$8.83	$4.52	$4.92
⅜	72.07	78.63	10.21	11.63	6.46	7.03
½	103.31	113.00	15.10	17.21	8.39	9.13
¾	139.77	152.88	20.51	23.07	11.78	12.75
1	167.12	182.79	27.34	30.76	14.56	15.75
1¼	224.85	245.94	50 13	56.40	19.41	21.01
1½	355.50	388.85	82.03	92.28	27.73	30.01
2	464.88	508 50	218.74	246 10	41.59	45.01
2½	585.30	637.74	483.04	543.46	55.46	60.02
3	714 17	776.30	558.23	628 06	69.32	75 02

CONDUIT BODIES AND FITTINGS—Black or galvanized

	Less than $10 list	$10 list to $100	$100 list and over
Standard package	10%	20%	28%
Less than standard package	5%	10%	20%

CUT-OUTS—Following are net prices each in standard-package quantities:

CUT-OUTS, PLUG

S. P. M. L.	$0.12	D. P. D. B.	$0.31
D. P. M. L.	.16	T. P. S. B.	.35
T. P. M. L.	.27	T. P. D. B.	.47
D. P. S. B.	.16		

CUT-OUTS, N. E. C. FUSE

	0-30 Amp.	31-60 Amp	60-100 Amp.
D. P. M. L.	$0.27	$0.70	$1.75
T. P. M. L.	.40	1 00	2.30
D. P. S. B.	.35	87	.....
T. P. S. B.	.67	1 50	.....
D. P. D. B.	.65	1.75	.....
T. P. D. B.	1.12	3 00	.....
T. P. to D. P. D. B.	.75	2 10	.....

FLEXIBLE CORD—Price per 1,000 ft. in coils of 250 ft.:

No. 18 cotton reinforced heavy	$21.09
No. 16 cotton reinforced heavy	24 00
No. 18 cotton reinforced light	17 00
No. 16 cotton reinforced light	20 25
No. 18 cotton Canvasite cord	15 25
No. 16 cotton Canvasite cord	17.50
No. 16 super service cord or similar	94 00
No. 14 super service cord or similar	143 00

NATIONAL ELECTRIC CODE FUSES, NON-REFILLABLE—

250-Volt	Std. Pkg.	List	600-Volt	Std. Pkg.	List
3-amp. to 30-amp.	100	$0.15	3-amp. to 30-amp.	100	$0.30
35-amp. to 60-amp.	100	.30	35-amp. to 60-amp.	100	.60
61-amp. to 100 amp.	50	.90	65-amp. to 100-amp.	50	1.50
101-amp. to 200-amp.	25	2.00	110-amp. to 200-amp.	25	2.50
201-amp. to 400-amp.	25	3.60	225-amp. to 400-amp.	25	5.50
401-amp. to 600-amp.	10	5.50	450-amp. to 600-amp.	10	8.00

Discount: Less 1-5th standard package, 60%; 1-5th to standard package, 65%; standard package, 70%.

RENEWABLE FUSES, ENCLOSED—List price each:

Sizes	250-Volt List-Price	600-Volt List-Price	Std. Pkg. Quantity	Carton Quantity
1 to 30-amp.	$0.50	$1.10	100	10
35 to 60-amp.	1.00	1.25	100	10
65 to 100-amp.	2.00	3.00	50	5
110 to 200-amp.	4.00	5.00	25	5
225 to 400-amp.	7.50	11.00	25	1
450 to 600-amp.	11.00	16.00	10	1
450 to 600-amp.	11.00	16.00	10	1

REFILLS—

1 to 30	$0.30 ea.	$0.55	100	100
35 to 60	.05 ea.	.06	100	100
65 to 100	.10 ea.	.10	50	50
110 to 200	.15 ea.	.15	25	50
225 to 400	.30 ea.	.30	25	25
450 to 600	.60 ea.	.60	10	10

Discount Without Contract—Fuses:	
Broken carton	5%
Unbroken carton but less than std. pkg.	22%
Std. pkg.	40%
Discount Without Contract—Renewals:	
Less than std. pkg.	Net list
Standard package	40%
Discount With Contract—Fuses:	
Broken cartons	10%
Unbroken cartons but less than standard package	26%
Standard package	42%
Discount With Contract—Renewals:	
Less standard package	Net list
Standard package	42%

FUSE PLUGS, MICA CAP OR CLEARSITT—

0-30 ampere, standard package (500)	$2.85
0-30 ampere, less than standard package	3.15

LAMPS—Below are present quotations in less than standard package quantities:

Straight-Side Bulbs Mazda B— Watts	Plain	Frosted	No. in Package	Pear-Shaped Bulbs or Bowl Enameled Mazda C— Watts	Clear	Frosted	No. in Package
10	$0.27	$0.32	120	50	$0.40	$0.45	60
15	.27	.32	120	75	.45	.55	60
25	.27	.32	120	100	.50	.55	24
40	.27	.32	120	150	.65	.70	24
50	.27	.32	120	200	.80	.85	24
60	.32	.37	120	300	1 25	1.35	24
				500	2 00	2.15	12
				750	3.50	3.70	8
				1,000	3.75	3.95	8

Standard pkg. quantities are subject to discount of 10% from list. Annual contracts ranging from $75.00 to $300,000 net allow a discount of 15 to 40% from list.

PLUGS, ATTACHMENT—

	Each
Porcelain separable attachment plug	$0 18
Composition 2-piece attachment plug	.27
Swivel attachment plug	.12
Small size—2 Pc. Plug—Composition	08½

RUBBER-COVERED COPPER WIRE—Per 1000 ft. f. o. b. New York:

No.	Solid Single Braid	Solid Double Braid	Stranded, Double Braid	Duplex
14	$7.20	$9.45	$11 10	$17.60
12	9.45	12.18	14.97	22.90
10	12.90	16.15	17 90	29.45
8	18.00	21.40	23 40	40 45
6	.....	.....	33 70	.....
4	.....	.....	45 87	.....
2	.....	.....	65 63	.....
1	.....	.....	88 43	.....
0	.....	.....	112.25	.....
00	.....	.....	134 00	.....
000	.....	.....	157 50	.....
0000	.....	.....	188 00	.....

SOCKETS, BRASS SHELL—

½ In. or Pendant Cap — Key Each	Keyless Each	Pull Each	¾ In. Cap — Key Each	Keyless Each	Pull Each
$0.36	$0.33	$0.50*	$0.42	$0.39	$0.56*

Less 1-5th standard package	30%
1-5th to standard package	40%
Standard package	45%

* Net.

WIRING SUPPLIES—

Friction tape, ¾ in., less 100 lb. 35c. lb., 100 lb. lots	33c lb.
Rubber tape, ¾ in., less 100 lb. 35c. lb., 100 lb. lots	33c lb.
Wire solder, less 100 lb. 27c. lb., 100 lb. lots	29c. lb.
Soldering paste, 2 oz. cans	$1 00 doz.

ENCLOSED SWITCHES, KNIFE—Safety type, externally operated, 250 d.c or a.c., N E.C.

TYPE "C" FUSED BOTTOM

Size, Amp.	Double Pole, Each	Three Pole, Each	Four Pole, Each
30	$4.50	$6.00	$7.25
60	7.50	8.25	10.50
100	10.50	13.00	22.50
200	16.00	20.00	36.00

Discounts:	
Less than $25.00 list value	30%
$25 to $50 list value	30-5%
$50 list value or over	35%